Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/ Center-TRACON Automation System (CTAS)

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15. Abstract

This report presents the results of an independent analysis of the accuracy of the trajectory modelers implemented in the User Request Evaluation Tool (URET) and Center-TRACON Automation System (CTAS) prototypes. These results are based on the completion of the first phase of a planned two phased effort. As originally envisioned, efforts during Phase 1 would develop a generic methodology to measure the trajectory prediction accuracy of any decision support tool (DST), which would be validated by applying it to CTAS and URET based on their currently adapted sites. In Phase 2, the methodology would be applied to URET and CTAS adapted to a common site and supplied with the same scenario. As such, the results from Phase 2 would have provided a common set of results based on the same site and scenario, allowing a comparison of the two trajectory modelers to be made, in support of research into the performance requirements for a common en route trajectory model. Due to funding cuts, this task was curtailed to the completion of Phase 1. The results from this phase do provide the FAA with an independent set of scenario-based trajectory accuracy statistics for each DST, but they cannot be used to compare the two DSTs due to the confounding site-specific factors.

A methodology was developed and CTAS and URET were measured based on one scenario each from their currently adapted sites (Fort Worth and Indianapolis, respectively). The Phase 1 study measured the spatial error between trajectory predictions versus the Host Computer System (HCS) track position reports, which were assumed to be the ground truth location of the aircraft. The spatial error consisted of horizontal and vertical errors. The horizontal error was further partitioned into two geometric components, lateral and longitudinal errors, representing the cross track and along track prediction errors. The focus of the analysis was on the overall trajectory accuracy of each DST, not on individual errors. A statistical analysis was performed on the overall accuracy of each modeler and the spatial errors have been summarized with descriptive statistics in the horizontal, lateral, longitudinal, and vertical dimension as a function of look ahead time. Inferential statistics were performed to determine whether specific factors (e.g., look ahead time, flight type, horizontal phase of flight and vertical phase of flight) had a significant effect on these performance statistics.

While the Phase 1 analysis cannot be used to compare the URET and CTAS trajectory modelers, the results do provide the FAA with an independent scenario-based set of trajectory accuracy measurements for each DST. In addition, a generic methodology has been developed that can be used to determine the performance requirements for a common en route trajectory model.

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Executive Summary

In the spring of 1998, the FAA Air Traffic Management (ATM) Engineering, Research and Evaluation Branch (ACT-250) was tasked by the En Route Area Work Team lead (at the time, AUA-540), of the Interagency Air Traffic Management Integrated Product Team (IAIPT), to conduct an independent assessment of the technical accuracy of the User Request Evaluation Tool (URET) and Center TRACON Automation System (CTAS) aircraft trajectory modeling algorithms. This study was initiated under IAIPT Joint Research Project Description (JRPD) 57 in support of research into the performance requirements for a common en route trajectory model. The task was partitioned into two parts. In Phase 1, a generic methodology to measure trajectory prediction accuracy would be developed and validated by applying it to CTAS and URET at their currently adapted sites. For Phase 2 the same methodology would be applied to CTAS and URET adapted to a common site and supplied with the same scenario. Due to funding limitations in FY99, this task was curtailed to the completion of only Phase 1, which is documented in this report. As such, it provides the FAA with an independent scenario based analysis of URET and CTAS trajectory prediction accuracy but these results can not be used to compare the two modelers due to the confounding site-specific factors.

A generic methodology was developed to analyze any Decision Support Tool's (DSTs) trajectory modeling. This methodology took the point of view of an air traffic controller using the DST. That is, a Controller viewing the aircraft predicted position data on the graphical user interface of the DST would wonder how accurate the predictions were into the future, e.g., 5 minutes, 10 minutes, 20 minutes, and beyond. The Controller is not necessarily interested in the interior workings of the tool, e.g., how recently the tool made its currently valid predictions, but rather how accurate the prediction is now, and into the future. Built upon this conceptual point of view of the user, a sampling process was used to obtain the measurement data. At selected times the actual position of the aircraft was obtained from the HCS radar track data and was compared with the position of the aircraft predicted by the tool.

The results presented are based on field data collected at Fort Worth Air Route Traffic Control Center (ARTCC) in January 1999 for CTAS and in Indianapolis Air Route Traffic Control Center (ARTCC) in February 1998 for URET. Both scenarios were approximately 7 to 7.5 hours in duration and provided about 2500 flights for analysis. The analysis was performed on approximately 17,000 URET trajectories and 32,000 CTAS trajectories. The main focus of the analysis was on the overall trajectory accuracy of each DST. The spatial errors have been summarized with descriptive statistics in the horizontal, lateral, longitudinal, and vertical dimensions as a function of look ahead time. Inferential statistics were performed to determine whether specific factors (i.e., look ahead time, flight type, horizontal phase of flight, and vertical phase of flight) had a significant effect on these performance statistics. For URET, the sample means of the horizontal error as a function of look ahead time range from 1.2 to 10.2 nautical miles for zero to 30 minutes look ahead time. The sample standard deviations range from 1.1 to 10.9 nautical miles. For CTAS, the sample means of horizontal error as a function of look ahead time range from 0.3 to 10.9 nautical miles for 0 to 30 minutes look ahead time. The sample standard deviations range from 0.9 to 11.2 nautical miles. For both URET and CTAS, the average and standard deviation of the horizontal error increased as look ahead time increased. In other words, the horizontal uncertainty of the trajectory predictions analyzed in this study increased by about 10 nautical miles on average as look ahead increased from zero to 30 minutes into the future.

While the Phase 1 analysis cannot be used to compare the URET and CTAS trajectory modelers, the results do provide the FAA with an independent scenario based set of trajectory accuracy measurements for each DST. All of the data from this study is stored in a large set of Oracle database tables in the WJHTC TFM Laboratory. This data can be made available to other members of the FAA community who may wish to analyze other factors, or answer other questions of interest, related to the trajectory prediction accuracy of URET and CTAS upon formal request to ACT-250. In addition, a generic methodology has been developed for the performance measurement of a common trajectory model. In FY99, this methodology and the parsing tools developed in this study will be applied to the development of DSR Workload Scenarios to be used for URET CCLD accuracy testing. With the planned adaptation of URET and CTAS to a common site (tentatively scheduled to occur in 2001) and anticipated funding availability in FY01, ACT-250 hopes to resume work on the proposed Phase 2 study to further address the FAA's efforts to determine the feasibility of a common en route trajectory model.

1. Introduction

1.1 Purpose

This report presents the results of an independent analysis of the accuracy of the aircraft trajectory modelers implemented in the User Request Evaluation Tool (URET) and the Center-TRACON Automation System (CTAS) prototypes. This study was conducted by the Air Traffic Management (ATM) Engineering, Research and Evaluation Branch (ACT-250) at the FAA William J. Hughes Technical Center (WJHTC). Quantitative measures of the trajectory accuracy of URET and CTAS are presented in terms of the following metrics: horizontal error (longitudinal error and lateral error) and vertical error. These results are based on analyses of field data obtained from the Indianapolis and Fort Worth Air Route Traffic Control Centers (ARTCCs) where the URET and CTAS prototypes, respectively, are currently implemented; as such, while this report provides useful information on the accuracy of the individual tools, the results cannot be used to compare the performance of the trajectory modelers.

1.2 Background

To achieve the goals of Free Flight, broad categories of advances in ground and airborne automation are required. The FAA has sponsored the development of two ground based ATM decision support tools (DSTs) to support the en route and arrival air traffic controllers. URET, developed by MITRE/CAASD, facilitates the controller's management of en route air traffic by identifying potential air traffic conflicts. CTAS, developed by NASA Ames Research Center, supports the controller in the development of arrival sequencing plans and the assignment of aircraft to runways to optimize airport capacity. A fundamental component of both URET and CTAS is the trajectory modeler, upon which the functionality provided by these tools is based. For example, URET uses its predicted trajectories to predict conflicts; CTAS uses its predicted trajectories to calculate meter fix crossing times. Thus, the trajectory accuracy, or the deviation between the predicted trajectory and the actual path of the aircraft, has a direct effect on the overall accuracy of the tool.

The prediction accuracy of URET and CTAS is a critical issue to be addressed in planning for Free Flight Phase 1 (FFP1) and the future integration of these tools. NASA Ames Research Center and MITRE/CAASD have each created and applied performance metrics for their specific tools (Bilimoria, 1998; Brudnicki et. al., 1998). The ATM Engineering, Research and Evaluation Branch (ACT-250) at the FAA WJHTC has defined a generic set of metrics that highlight the performance of any decision support tool: trajectory accuracy, conflict prediction accuracy, prediction stability and conflict notification timeliness (WJHTC/ACT-250, 1997 and Cale et al., December 1998). Since these metrics are independent of a particular system's design choices, they provide common measures to evaluate the performance of different systems. In early 1998, ACT-250 applied the conflict prediction accuracy metrics to URET (Cale et al., April 1998). Following the completion of the URET conflict prediction accuracy assessment, ACT-250 was tasked by the Interagency ATM Integrated Product Team (IAIPT) En Route Area Work Team lead (at that time, AUA-540) to conduct an independent assessment of the technical accuracy of the CTAS and URET trajectory modeling algorithms. This report focuses on the initial application of the trajectory accuracy metrics to URET and CTAS.

1.3 Scope

ACT-250's original plan for the trajectory accuracy study called for a two-phased effort. During the first phase, the necessary data reduction and analysis tools would be developed and validated

by applying them to URET and CTAS based on the ARTCCs to which these DSTs were currently adapted (i.e., Indianapolis and Fort Worth). Phase Two then called for both systems to be adapted to a common ARTCC, with the trajectory accuracy study conducted based on this common data and a report issued. Toward the end of Phase One, funding was cut for ACT-250's IAIPT tasks for FY99 and ACT-250's focus shifted to the development of scenarios to be used for the FFP1 URET Core Capability Limited Deployment (CCLD) accuracy testing. Since the initial trajectory study was almost completed and many of the tools being developed were required by the scenario development task, it was decided to complete this study and provide a report even thought the results are limited to the Phase One effort. Therefore, while the results presented provide an estimation of the accuracy of the individual tools' trajectory modelers, this data can not be used to compare the two modelers because it is based on information from two different centers at different time periods with different weather characteristics.

1.4 Document Organization

This report is organized into five sections and three appendices. Section 2 provides a detailed description of the methodology employed to conduct the trajectory accuracy study. Sections 3 and 4 describe the scenarios, and observations and results for the URET and CTAS studies, respectively, and Section 5 provides a summary of the study. Document references and a list of acronyms are also provided. In addition, three appendices are provided: detailed descriptions of the data analyzed for each tool are provided in Appendix A, standard deviation statistical plots of results are provided in Appendix B, and additional flight observation examples are provided in Appendix C.

2. Trajectory Accuracy Study Methodology

The WJHTC ATM Engineering, Research and Evaluation Branch (ACT-250) has been involved in the development and application of metrics to assess various aspects of decision support tools since early 1997 (WJHTC/ACT-250, 1997; WJHTC/ACT-250, 1998; Cale et. al, April 1998; Cale et. al, December 1998). The fundamental characteristic of these metrics is their independence from any particular DST's design choices, thus providing common measures to evaluate the performance of different systems. The approach employed for this study used field data recorded at two of the ARTCCs where the URET and CTAS prototypes are currently implemented.

The effective estimation of the trajectory accuracy metrics required considerable data to be collected and analyzed. A generic set of data reduction and analysis tools was developed, building upon ACT-250's Traffic Flow Management (TFM) Laboratory's Oracle database system and tools previously developed for the URET Conflict Prediction Accuracy Study (Cale et. al., April 1998). This section describes these generic techniques as they were used in this trajectory study, and provides information on the definitions used throughout the study, the sources of data and the data processing methodology, the data processing reports that were generated, and the analysis performed. Sections 3.2 and 4.2 contain observations for URET and CTAS, respectively, that demonstrate the application of this methodology.

2.1 Overview

Three major process areas comprise the Trajectory Accuracy Study methodology (shown in Figure 2.1-1):

1. **Field Data Parsing** - The recorded field data, which may be provided in different formats, is parsed to extract the flight plan data, the track data, and the trajectory data into a common format. The details of this DST-specific parsing are provided in Sections 3.1 and 4.1.
2. **Flight Plan and Track Data Processing** - The software in this process area filters and characterizes the track data, placing the results in tables in the TFM Laboratory Oracle database. Details on this processing are provided in Section 2.4.
3. **Trajectory Data Processing and Trajectory Report Generation** - During these processes, the trajectory data is sampled and compared with the track data, the metrics are calculated and placed into tables in the TFM laboratory Oracle database, and reports are generated. Trajectory data sampling is necessary due to the differences in trajectory creation methods employed by URET and CTAS (i.e., CTAS computes a new trajectory every 12 seconds for every track update, while URET's trajectory creation is mainly event driven); on average, 10-12 times more trajectories were created for CTAS than for URET. Because of this, a sampling technique was designed to create equivalent sets of trajectory data for analysis. Details on this processing are provided in Section 2.5.

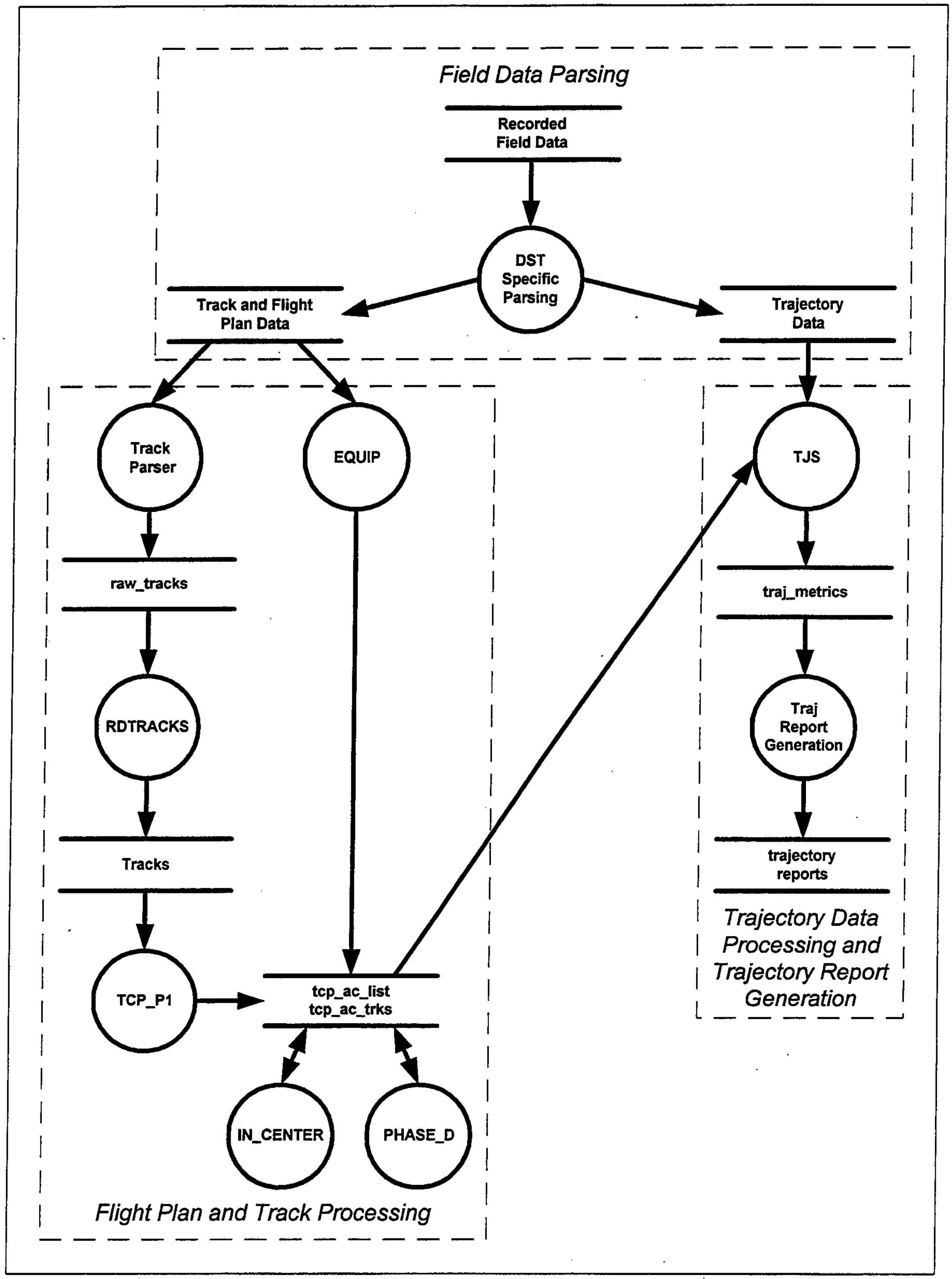

Figure 2.1-1: Trajectory Accuracy Study Methodology Overview

2.2 Definitions

This section defines the basic terms used throughout this report. These are grouped into three categories: data definitions, metrics definitions, and factor definitions.

2.2.1 Data Definitions

Three types of data were used as input to this study: flight plan, track, and trajectory data.

2.2.1.1 Flight Plan Data

A flight plan consists of time stamped records containing information about the aircraft's flight, including: aircraft identification (ACID), computer identification number (CID), aircraft type, coordination fix, coordination time, and intended route of flight. For both URET and CTAS, the flight plan data for this study was recovered from flight plan and flight plan amendment messages output from the ARTCC Host Computer System (HCS) and recorded by the URET or CTAS interface software.

2.2.1.2 Track Data

Track data represents the position of an aircraft as reported by the ARTCC HCS. An aircraft's track is represented by a sequence of four-dimensional data points, with each data point consisting of three spatial coordinates (denoted X_i, Y_i, and Z_i) and their associated time (denoted T_i,), where i refers to a particular data point. For both URET and CTAS, the track data for this study was recovered from track messages output from the ARTCC HCS and recorded by the URET or CTAS interface software.

2.2.1.3 Trajectory Data

Trajectory data represents the position of an aircraft as predicted by the DST into the future. A trajectory is a sequence of four-dimensional data points, with each data point consisting of three spatial coordinates (denoted X_i, Y_i, and Z_i) and their associated time (denoted T_i,), where i refers to a particular data point. The trajectory data for this study was directly captured from the URET and CTAS trajectory modelers.

2.2.2 Metrics Definitions

Trajectory accuracy can be measured as the spatial difference between the predicted path of the aircraft determined by the DST and the aircraft's actual path. This difference is the slant range distance between the predicted trajectory position and the actual track position at a common time. A perfect prediction would have a slant range of zero.

For this study, trajectory accuracy was measured as the difference between the URET or CTAS predicted trajectory and the tracked position reports received from the ARTCC HCS. This slant range distance was decomposed into three orthogonal components: longitudinal error and lateral error in the horizontal plane, and vertical error perpendicular to the horizontal plane. Both the longitudinal and lateral errors are also orthogonal components of the horizontal error. The horizontal error is the slant range's projection onto the horizontal plane. These errors are actually vectors, however statistical analysis was performed only on their scalar lengths and a sign convention was used for direction, where appropriate. The details for estimating these metrics are presented in Section 2.5.1.2.

2.2.2.1 Longitudinal Error

The longitudinal error represents the along track distance difference between a track and its trajectory. This error, depicted in Figure 2.2-1, lies in the horizontal plane defined by a track point

and two consecutive trajectory points. As seen in Figure 2.2-1, a positive longitudinal error indicates that at a corresponding point in time the aircraft is ahead of where the trajectory predicted it would be.

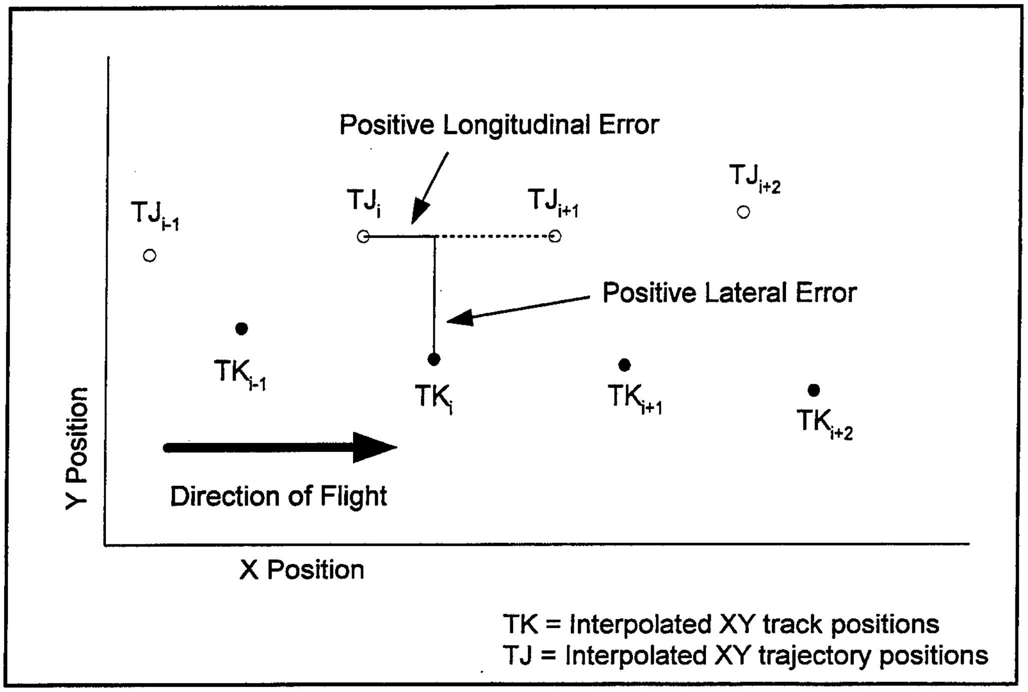

Figure 2.2-1: Longitudinal and Lateral Errors

2.2.2.2 Lateral Error

The lateral error represents the side to side, or cross track, difference between a track and its trajectory. This error, also represented in Figure 2.2-1, lies in the horizontal plane defined by a track point and two consecutive trajectory points. A positive lateral error indicates that the aircraft is to the right of the predicted trajectory at a corresponding point in time.

2.2.2.3 Vertical Error

The vertical error represents the difference between the tracked altitude and the predicted altitude. This error, depicted in Figure 2.2-2, lies perpendicular to the horizontal plane. A positive vertical error indicates that at a corresponding point in time the aircraft is above where the trajectory predicted it would be.

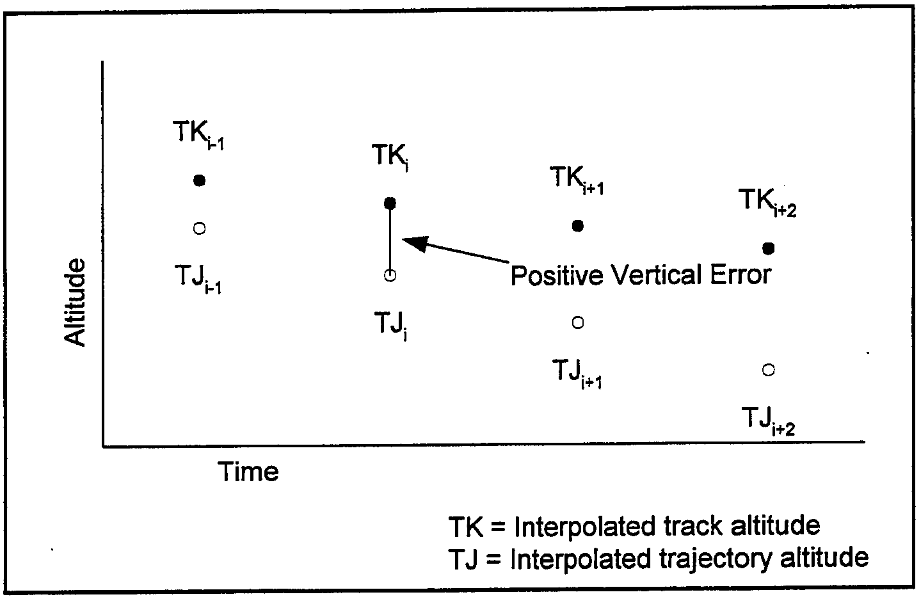

Figure 2.2-2: Vertical Error

2.2.3 Factors Definitions

Various factors that have the potential of affecting the accuracy of a trajectory modeler were examined during this study. These factors, which include trajectory build time, early trajectory, look ahead time, phase of flight, flight type and aircraft type, are defined in the following sections.

2.2.3.1 Trajectory Build Time

During the life of an aircraft track, a trajectory modeler computes numerous trajectories, each with an associated build time. Since, the trajectory accuracy metrics were computed at a number of sample times along an aircraft track it was necessary to establish criteria for selecting which trajectory to use in these computations. The trajectory selected for a specific sampling time along an aircraft track was the trajectory with the most recent build time, not exceeding the sample time. The determination of this factor is described in Section 2.5.1.1.

2.2.3.2 Early Trajectory

Depending on the method employed for creating trajectories (i.e., upon receipt of every track point or event driven), it is possible for a trajectory to be computed before the start of the track data. For this study, these are identified as "early trajectories". These trajectories are built strictly with the flight plan without HCS track information. The determination of this factor is described in Section 2.5.2.

2.2.3.3 Look Ahead Time

Associated with the error measures for a pair of points is a look ahead time. This look ahead time is the difference between the time point at which the metrics are computed for a sampled trajectory/track position and a base time. The base time represents the first calculation of the metrics taken among a sequence. The sequence starts by taking the current track point and a time coincident trajectory point off the currently available trajectory. The first point is the base time and then every parameter number of seconds, or look ahead time, into the future the metrics are

calculated on this same trajectory. The sequence iterates again every parameter number of seconds based on the sampling methodology defined in Section 2.5.1.1.

It is important to note that the look ahead time is based on the start of each sampling interval and is not directly related to the age of the trajectory as defined in other studies. For example, MITRE/CAASD defines look ahead time to be the difference between the trajectory build time and the time into the future a metric is calculated along that trajectory (Brudnicki, August 1995). In the ACT-250 study definition, a look ahead time of zero may be calculated on a trajectory that has an age of more than zero. The determination of this factor is described in Section 2.5.

2.2.3.4 Phase of Flight

In the horizontal plane an aircraft can be considered to be either flying straight or turning. In the vertical plane an aircraft can be considered to be either flying level, ascending, or descending. The determination of these factors is described in Section 2.4.6.

2.2.3.5 Flight Type

With respect to an ARTCC, an aircraft can be considered to be:

- overflight - the aircraft track begins outside the center boundary, flies through the center, then ends outside the center boundary
- departure - the aircraft track begins at an airport within the center and ends outside the center boundary
- arrival - the aircraft track begins outside the center boundary and ends at an airport within the center
- internal - the aircraft track begins and ends at an airport within the center.

The details for estimating this factor are presented in Section 2.4.2.

2.2.3.6 Aircraft Type

The aircraft type is available as a part of an aircraft's flight plan message. For both DSTs, the aircraft type is an important factor in modeling the aircraft's flight profile. The frequency of the top 20 aircraft types were reported for each data set used (see Sections 3.1 and 4.1), however an analysis of the effect of the aircraft type as a factor was left for future study.

2.3 Data Sources

The source of the flight plan and track data used for this study was recorded at the Indianapolis (ZID) and Fort Worth (ZFW) ARTCCs. Section 2.4 describes the generic techniques used to process this data. Specific data processes and procedures required for URET and CTAS are described in Section 3.1 and Section 4.1, respectively.

2.4 Flight Plan and Track Data Processing

Figure 2.4-1 provides a data flow diagram logically describing the data files and processes used to process the flight plan and track data. This processing was automated through a UNIX shell script that performed numerous functions through six primary processes: Track Parser, EQUIP, RDTRACKS, TCP_P1, IN_CENTER, and PHASE_D. These are further described in the following subsections.

2.4.1 Track Parser

The Track Parser process consists of a UNIX shell script and C++ programs that parse and sort the track data for input into the Oracle database table RAW_TRACKS.

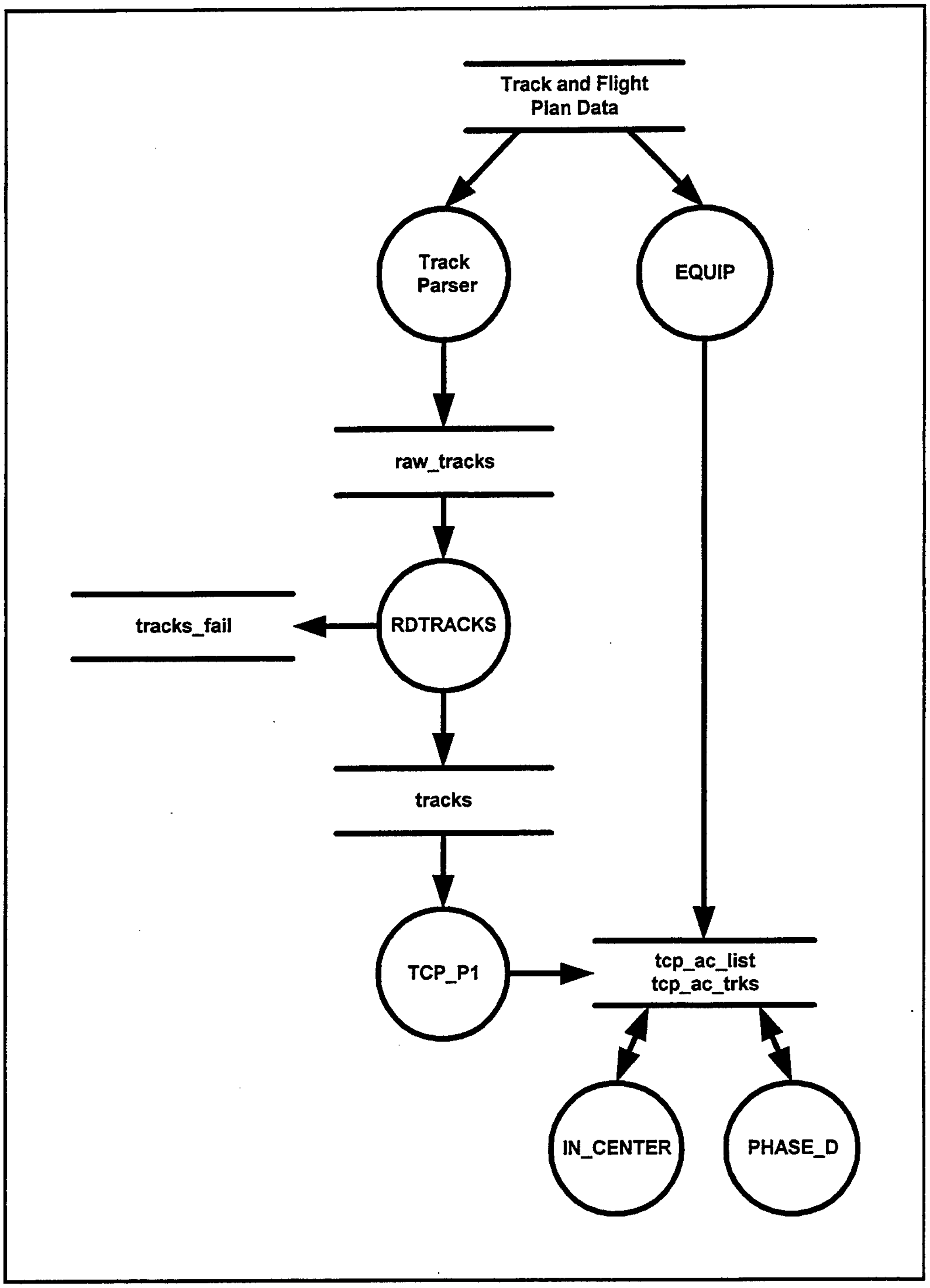

Figure 2.4-1: Flight Plan and Track Data Processing

2.4.2 EQUIP

EQUIP is a C program that extracts flight plan information and places it in the *tcp_ac_list* and *tcp_ac_trks* Oracle database tables. This information includes: the origin and destination airports, the flight type (arrival, departure, overflight, and internal), and the aircraft type and its equipage.

2.4.3 RDTRACKS

RDTRACKS is a C program that filters the RAW_TRACKS data to establish the "ground truth" tracks to which the trajectories are compared. RDTRACKS uses the URET and CTAS HCS tracks from their respective interface recorder files and produces files that are loaded into the TFM laboratory Oracle database to create the *tracks* and *tracks_fail* tables (described in WJHTC/ACT-250, 1999). The specific functions performed by RDTRACKS are described in the following subsections.

2.4.3.1 Correction of HCS Radar Track Position Reports

The radar track data supplied to the tools by the HCS contained inaccuracies and needed to be corrected before the error measurements could be made against the DST's trajectory predictions. For example, the following faults were found in the HCS track data:

- **Missing Track Reports -** Nominally the HCS supplies a new track report every 12 seconds. However, there were situations where the HCS omitted track reports, creating a gap in the position data (occasionally five or 10 minutes long). Short gaps (time gaps of less than two minutes) were patched by linear interpolation in all dimensions. Long gaps (time gaps of more than two minutes) were not patched and no accuracy measurements were made for these sections of the aircraft flight path.
- **Stationary Track Reports -** Frequently the HCS gave two or more successive track reports that had identical values for X, Y, and Z. That is, according to the HCS the aircraft had not moved (usually the HCS caught up with the next track report). This problem was fixed by linear interpolation.
- **Inconsistent Track Reports** - Because of its inertia, an aircraft is not able to make abrupt changes in velocity and position. Therefore, the distance traveled between position reports changes slowly. An abrupt change in track step size is not physically possible. A position report was considered to be inconsistent with the previous track report when an abrupt change occurred. Usually the position reports became consistent within a few track reports. Small amounts of inconsistent data were patched (i.e. less than two minutes), while large amounts (i.e. greater than two minutes) were not patched and measurements were not made during or beyond these gaps.
- **Jitter** – The position reports "bounce around" rather than following a smooth track as the aircraft is actually doing. This effect is noise or jitter on the position reports and is fairly small. It may be that the jitter exists in spite of the smoothing that the HCS does on the radar reports because of errors in the time data reported. As usual for real time processing systems, the data is not time stamped when it is collected. The time stamp is added later with reduced accuracy. For the statistical analyses performed in this study, the jitter was ignored. However, future studies may remove this additional source of error, using data smoothing techniques.

In addition to the track faults, there are differences in the methods by which URET and CTAS time stamp the track position reports from the HCS. RDTRACKS requires equally spaced track position reports, which URET supplies. CTAS track reports are not time stamped at equally spaced 12 second intervals but exactly as received downstream from the HCS interface.

Therefore, it was necessary to recover the HCS time values. This was done by rounding to the nearest whole second value and then these rounded values were rounded to the nearest integer multiple of 12 seconds. This was done in such a way as to minimize the total time adjustments for the entire track of the aircraft.

2.4.3.2 Track Processing Steps

The following processing was done to establish a good track history for an aircraft. If one value in a track report failed a test, the entire record was discarded. These tests did not ensure that a track report was accurate, but track reports that were clearly in error were excluded. If a track could not be initialized, the aircraft was not used in the study. At the start of each flight's track reports or following a large gap in time or spatial inconsistency, a flight's tracks are initialized. The initialization and continuous processing of the HCS track data is described below.

- **Prune Leading and Trailing Zeros** - Often the first one or two track reports for an aircraft had zero values for altitude. Similarly the last few records sometimes had zero altitude values. These reports were discarded.
- **Initialize Track** - The track was initialized by finding three good, contiguous track reports. A track report was considered good if it passed three tests:
  1. **Values Test** - The values test was used to catch gross errors in the aircraft position data. To pass the Values Test, Z had to be greater than zero and the absolute values of X and Y had to be less than 1000.
  2. **Delta Time Test** - To pass the Delta Time Test, the time of the track report had to be 12 seconds later than the time of the immediately preceding track report.
  3. **Fixed Delta Values Test** - To pass the Fixed Delta Values Test, the position of the aircraft in the horizontal (XY) plane must not have changed (in one 12 second step) by more than a maximum threshold value (3.0 nautical miles) nor less than a minimum threshold value (0.1 nautical miles). These threshold values correspond to aircraft speeds of 900 knots and 30 knots, respectively. In addition, the altitude of the aircraft could not have changed by more than a threshold value of 2000 feet, which corresponds to a climb or descent of 10,000 feet per minute. (Note that military aircraft were excluded from this study.)

After three good, contiguous track reports were found, the above three tests were repeated for each successive track report. Every record that passed all of the tests was passed unchanged to the next processing step in TCP_P1. If a report failed a test, an attempt was made, usually successfully, to fix the record by inserting new values obtained through interpolation between a previous good report and a later good report. There were two cases to handle: a time gap (missing data), and a bad data gap (one or more records were in error).

- **Time Gap Processing** - When a time gap in the data was found, a search was started for an acceptable next track report, starting with the current track report. Each successive track report was tested in turn. An acceptable next track report had to pass three tests: the Values Test described above, and the Variable Delta Values Test and the Maximum Time Gap Test, described below:
  1. **Variable Delta Values Test** - A prediction was made of where the aircraft would be if it maintained the same ground velocity as it had before the time gap. This predicted position was compared to the position reported by the candidate track report. The test was passed if the two positions were close enough to each other (three nautical miles). The average ground velocity was calculated using the last four position reports before the time gap.

2. **Maximum Time Gap Test** - The Maximum Time Gap Test determined if the time difference between the last good track report and the candidate next good report was less than or equal to two minutes. It was assumed that track data can be interpolated accurately for a time gap less than two minutes. This parameter setting of two minutes allowed up to nine successive position reports to be interpolated.

If a candidate track report failed either the Values Test or the Variable Delta Values Test, or both, the next track report was selected for testing. If the candidate track report passed the Values Test and Variable Delta Values Test, but failed the Maximum Time Gap Test, the track was re-initialized, whenever possible. If the track could not be re-initialized, it was terminated. If the search reached the end of the track data without finding a record which had passed all three tests, the track was terminated. If the candidate track report passed all three tests, it was output and used with the last good report to estimate, using linear interpolation, the missing track report positions in the time gap. The interpolation inserted track reports into the missing time slots and also replaced the track reports which failed the tests in the search for the next good report.

- **Bad Data Gap Processing** - A bad data gap was detected when a track report passed the Delta Time Test and the Values Test but failed the Fixed Delta Values Test. A search was then started to find the next good record. The search process was the same for a bad data gap as for a time gap. A search was started for an acceptable next track report, starting with the current track report. Each successive track report was tested in turn. An acceptable next track report had to pass three tests: the Values Test, the Variable Delta Values Test and the Maximum Time Gap Test, described above. When a candidate track report was found which passed all three tests, it was output and used with the last good report to estimate, using linear interpolation, the correct values of X, Y, and Z for the track report positions in the bad data gap. The interpolation inserted the corrected values into the track reports in the bad data gap. Then regular track processing was resumed. If a good next report could not be found, the track was terminated. If a next report passed the Values and the Variable Delta Values Tests, but failed the Maximum Time Gap Test, the track was re-initialized, if possible. If the track could not be re-initialized, it was terminated.

2.4.4 Track Conflict Probe

TCP_P1 is an Oracle Standard Query Language Plus (SQL/Plus) program that performs the interpolation of the track data. Although the HCS track reports normally are generated at 12-seconds intervals, for this study the track data was interpolated using a uniform 10-second time interval and synchronized with the hour.

An example of the relationship between recorded field data and interpolated aircraft tracks is shown in Figure 2.4-2. In this figure the **X**'s represent positional data generated by RDTRACKS at four time points. This data is specified in a time-of-day form and represents the aircraft's position at 16:25:13, 16:25:25, 16:25:37, 16:25:49, and 16:26:01. The **O**'s represent the interpolated positions with the time specified as the number of seconds elapsed since midnight. This interpolation was calculated using the MITRE/CAASD URET function CFP_POSIT (see Cale et. al., 1997, Section 3.1.9). This function uses a 2^{nd} order method in which the acceleration is assumed to be constant throughout the interpolation interval. The ground speeds are needed as input for the quadratic interpolation method; if they are not available this method degenerates to a linear interpolation method.

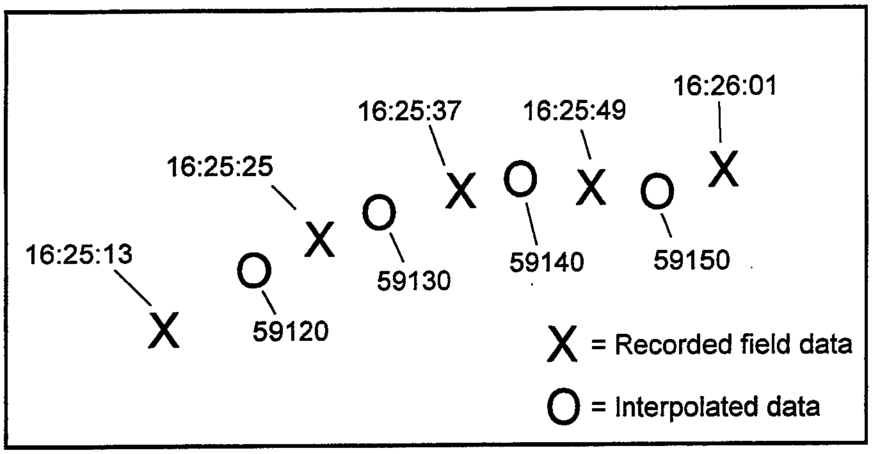

Figure 2.4-2: Interpolation of Recorded Aircraft Track Data

The following equations were used for quadratic interpolation where:

x is the desired interpolated X coordinate at time t,

x_1 is the value of x at time t_1,

x_2 is the value of x at time t_2,

y is the desired interpolated Y coordinate at time t,

y_1 is the value of y at time t_1,

y_2 is the value of y at time t_2, and $t_1 < t < t_2$.

In addition, for quadratic interpolation it was assumed that the acceleration was constant over the interpolation interval. The acceleration was then equal to the difference of the velocities at the start and end points of the interval divided by the length of the interval in time.

Let,

v_1 be the velocity of the aircraft at time t_1,

v_2 be the velocity of the aircraft at time t_2,

v_{1x} and v_{1y} be the X and Y components of the velocity v_1, and

v_{2x} and v_{2y} be the X and Y components of the velocity v_2.

Then the interpolated coordinate positions are

$$x = \frac{Ax_1 + Bx_2}{C} \qquad \textbf{Equation 2.4-1}$$

and

$$y = \frac{Dy_1 + Ey_2}{F} \qquad \textbf{Equation 2.4-2}$$

where

$$A = (v_{1x} - v_{2x})(t_2 - t)^2 + 2v_{2x}(t_2 - t_1)(t_2 - t) \qquad \textbf{Equation 2.4-3}$$

$$B = (v_{2x} - v_{1x})(t - t_1)^2 + 2v_{1x}(t_2 - t_1)(t - t_1) \qquad \textbf{Equation 2.4-4}$$

$$C = (v_{1x} + v_{2x})(t_2 - t_1)^2 \qquad \textbf{Equation 2.4-5}$$

$$D = (v_{1y} - v_{2y})(t_2 - t)^2 + 2v_{2y}(t_2 - t_1)(t_2 - t) \qquad \textbf{Equation 2.4-6}$$

$$E = (v_{2y} - v_{1y})(t - t_1)^2 + 2v_{1y}(t_2 - t_1)(t - t_1) \qquad \textbf{Equation 2.4-7}$$

$$F = (v_{1y} + v_{2y})(t_2 - t_1)^2 \qquad \textbf{Equation 2.4-8}$$

2.4.5 IN_CENTER

The IN_CENTER process determines if the interpolated track points fall within the center boundary. It uses an algorithm very similar to the MITRE/CAASD URET GM_REGN function (see Cale et. al., 1997, section 3.4.17) which determines if aircraft are within a protected or inhibited airspace. Since this study's application of this program was only interested in the end of an aircraft's track reports, all tracks were first flagged to be inside the center boundary. The algorithm was adapted to flag whether the track was outside the center boundary, starting from the end of the track reports and going backwards in time order. Processing was stopped for a flight's track as soon as it re-entered the center's airspace. For example, if an overflight had 100 interpolated track reports whose last 10 tracks were outside the center boundary (i.e. the 91st to 100th), this process determined each of the last 10 reports to be outside the Center boundary and the processing was terminated on the 90th track report when it was determined to be inside the Center.

The flag of inside or outside a center boundary, applied to the end of a flight's interpolated tracks, is utilized in the trajectory sampling process, since the trajectory prediction on tracks at the end of a flight outside the center are not processed for spatial prediction errors. This is an approximate method of excluding error calculations on the end portion of a flight transferring to another ARTCC and thus to another HCS and DST not included in the study.

2.4.6 PHASE_D

PHASE_D is a C program that determines the phase of flight of the aircraft in the horizontal and vertical directions, as discussed in the following subsections.

2.4.6.1 Horizontal Phase of Flight

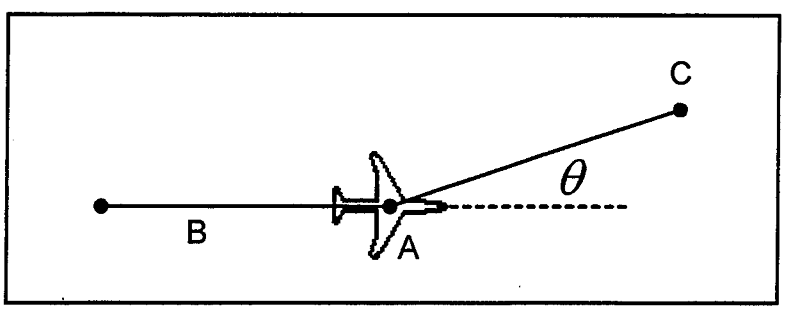

Figure 2.4-3: Horizontal Phase of Flight

The horizontal phase of flight for an aircraft, with respect to the ground, was defined as one of three states: straight, turning right, or turning left. The state was determined as follows: The point labeled A in Figure 2.4-3 represents the track point at which the aircraft's horizontal phase of

flight is being determined. The point labeled B is a point along the interpolated track a parametric number of points (one point in this study) earlier in time than the point being examined. The point labeled C is a point along the track a parametric number of points (one point in this study) later in time than the point being examined. Then the vector V is defined as the normalized vector cross product of the vector from point B to A and the vector from point A to C, i.e.:

$$V = \frac{V_{BA} \times V_{AC}}{\|V_{BA}\| \|V_{AC}\|} \qquad \textbf{Equation 2.4-9}$$

where

V_{BA} is the vector defined by joining B to A

and

V_{AC} is the vector defined by joining A to C.

The magnitude of the vector V is the sine of the local change in bearing angle of the aircraft and can be used to determine the horizontal phase of flight, i.e., if the aircraft is flying straight this angle will be zero or close to zero. If the aircraft is turning the sine will not be close to zero and the sign of the sine of this angle will indicate whether the aircraft is turning left or right.

Since the vectors V_{BA} and V_{AC} are in the horizontal XY plane their vector cross product V is a vector perpendicular to the horizontal plane; i.e., coincident with the vertical or Z axis. In the NAS ARTCC coordinate system up is positive and down is negative. Therefore the sense of V is positive for a left turn and negative for a right turn. To determine whether the aircraft is flying straight or turning, the magnitude of V is compared to a threshold to minimize the effect of track position noise on the measurement.

Let the coordinates of the point A be x_a and y_a, the coordinates of the point B be x_b and v_b, and the coordinates of the point C be x_c and y_c. Then the components of the vectors V_{BA} and V_{AC} are:

$$V_{BA} = \begin{bmatrix} x_a - x_b \\ y_a - y_b \\ z_a - z_b \end{bmatrix} = \begin{bmatrix} v_{BAx} \\ v_{BAy} \\ v_{BAz} \end{bmatrix} \qquad \textbf{Equation 2.4-10}$$

$$V_{AC} = \begin{bmatrix} x_c - x_a \\ y_c - y_a \\ z_c - z_a \end{bmatrix} = \begin{bmatrix} v_{ACx} \\ v_{ACy} \\ v_{ACz} \end{bmatrix} \qquad \textbf{Equation 2.4-11}$$

Since the vectors are defined to be in the horizontal plane, the z components are all zero. The norms or magnitudes of the vectors are:

$$\|V_{BA}\| = \sqrt{v_{BAx}^2 + v_{BAy}^2} \qquad \textbf{Equation 2.4-12}$$

$$\|V_{AC}\| = \sqrt{v_{ACx}^2 + v_{ACy}^2} \qquad \textbf{Equation 2.4-13}$$

The cross product of the vectors V_{BA} and V_{AC} has a single component in the z direction, which is calculated as:

$$Q = v_{BAx} v_{ACy} - v_{ACx} v_{BAy}$$ **Equation 2.4-14**

Normalizing the cross product by dividing by the magnitudes of the vectors V_{BA} and V_{AC} gives the sine of the angle between the vectors which is the local change in aircraft course bearing θ.

$$\sin\theta = \frac{Q}{\|V_{BA}\|\|V_{AC}\|}$$ **Equation 2.4-15**

and

$$\theta = \sin^{-1}\left(\frac{Q}{\|V_{BA}\|\|V_{AC}\|}\right)$$ **Equation 2.4-16**

This calculation of θ is valid for angles of up to 90 degrees, left or right. For angles from 90 degrees to 180 degrees, left or right, the value of the angle is incorrect, but the sign of the angle is correct. For turn angles greater than 180 degrees, the angle and the sign are incorrect.

The absolute value of $\sin\theta$ is compared to a threshold to determine whether or not the aircraft is turning. If the aircraft is turning, a positive value of $\sin\theta$ says the aircraft is turning to the left, a negative value says the aircraft is turning to the right.

In this study, a turn is determined by a nine degree angle (or greater) generated by the two segments drawn from the previous position to the current position and the current position to the next position report. The threshold was determined from observation of several flights in both Indianapolis and Fort Worth ARTCCs. In the future, data smoothing techniques may be employed to further enhance the algorithm changing this threshold angle.

2.4.6.2 Vertical Phase of Flight

The vertical phase of flight for an aircraft was defined as one of three states: level, ascending, or descending. This state was determined by selecting a track data point a parametric number of points (one point in this study) earlier than the point being examined and a track data point a parametric number of points (one point in this study) later than the point being examined. The altitude difference between the earlier point and the later point divided by the time difference between the two points is an estimate of the aircraft's rate of climb or descent. If the absolute value of the measured rate of climb is less than a parametric threshold value (150 feet in this study) the aircraft is considered to be in level flight. If the measured rate of climb is greater than a positive parametric threshold (150 feet in this study) the aircraft is considered to be ascending. If the measured rate of climb is less than a negative parametric threshold (-150 feet in this study), then the aircraft is considered to be descending.

2.5 Trajectory Data Processing and Trajectory Report Generation

Figure 2.5-1 provides a data flow diagram logically describing the data files and processes used to sample the trajectory data and to generate the trajectory reports. This processing consists of the Trajectory Sampling Program (TJS) and the Trajectory Report Generation Program (TRG), discussed in subsections 2.5.1 and 2.5.2.

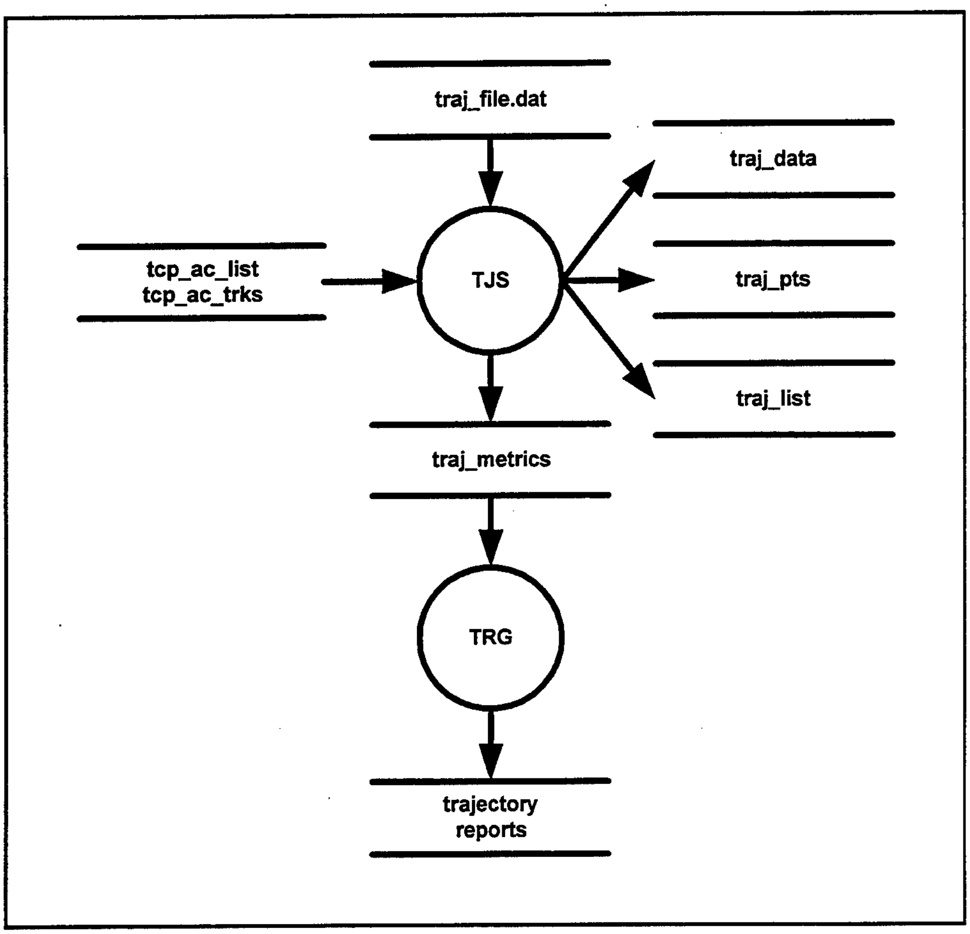

Figure 2.5-1: Trajectory Data Processing and Trajectory Report Generation

2.5.1 Trajectory Sampling Program (TJS)

The Trajectory Sampling Program (TJS) is a C++ program that uses the Oracle Pro*C/C++ Precompiler (Release 8.0) to interface with the Oracle database in the TFM laboratory.

2.5.1.1 Trajectory Sampling

The URET and CTAS trajectory modelers evaluated by this study both compute time-based four-dimensional trajectories. However, they have different design philosophies regarding when these trajectories are calculated.

URET calculates an initial trajectory for each aircraft, then constructs a new trajectory for a given aircraft whenever:

1. A new flight plan or flight plan amendment message is received from the HCS, or new or updated interfacility flight plan information is received from a neighboring URET system.

2. A hold message is received from the HCS that indicates the aircraft is entering or leaving a holding pattern.

3. URET determines that a new trajectory is necessary to reconform an aircraft's trajectory with the aircraft's actual position. This can happen when the HCS track data is found to be a parametric distance (nominally 1.5 to 2.5 nautical miles) from the trajectory or if the current trajectory is older than a parametric value (e.g. 20 minutes).

CTAS, on the other hand, calculates a new trajectory for each aircraft upon receipt of HCS track data each processing cycle.

ACT-250 devised a trajectory sampling technique that is independent of the design approach of either trajectory modeler. The line in Figure 2.5-2 labeled "Track" represents the time line for an aircraft track. The time point labeled T_S represents the initial interpolated track point. The sampling time to start computing metrics for this track is represented by T_0, where

$$T_0 = T_S + \text{TRAJ\_DELTA\_TIME} \qquad \textbf{Equation 2.5-1}$$

TRAJ_DELTA_TIME is a parametric value (40 seconds) which establishes the starting time at a point where the track is more stable.

The trajectories for this example aircraft are presented in Figure 2.5-2 by the time lines labeled $Traj_0$, $Traj_1$, $Traj_2$, and $Traj_3$. The trajectory to be sampled for a particular track sampling time is the trajectory with the latest trajectory build time not exceeding the track sampling time. Selected trajectories were interpolated using techniques similar to the techniques for interpolating tracks described in Section 2.4.4. In Figure 2.5-2, $Traj_0$ would be sampled for sampling time T_0. This point is labeled $T_{0,0}$ and represents the look ahead time of zero seconds for the trajectory sampling time T_0.

Metrics would be computed at the time point labeled T_0 and at the incremented time points $T_{0,1}$ and $T_{0,2}$ where

$$T_{i,j+1} = T_{i,j} + \text{TRAJ\_LOOKAHEAD\_TIME} \qquad \textbf{Equation 2.5-2}$$

TRAJ_LOOKAHEAD_TIME is the parametric sampling interval (300 seconds) for a specific sampling time.

The trajectory sampling process continues until either: the end of the track is reached, the end of the trajectory is reached, or the time exceeds T_0 + TRAJ_LOOKAHEAD_WIN, a parametric input (1800 seconds). Then the next track sampling time T_i will be computed as:

$$T_{i+1} = T_i + \text{TRAJ\_SAMPLE\_TIME} \qquad \textbf{Equation 2.5-3}$$

TRAJ_SAMPLE_TIME is the parametric sampling interval (120 seconds) for sampling a specific track.

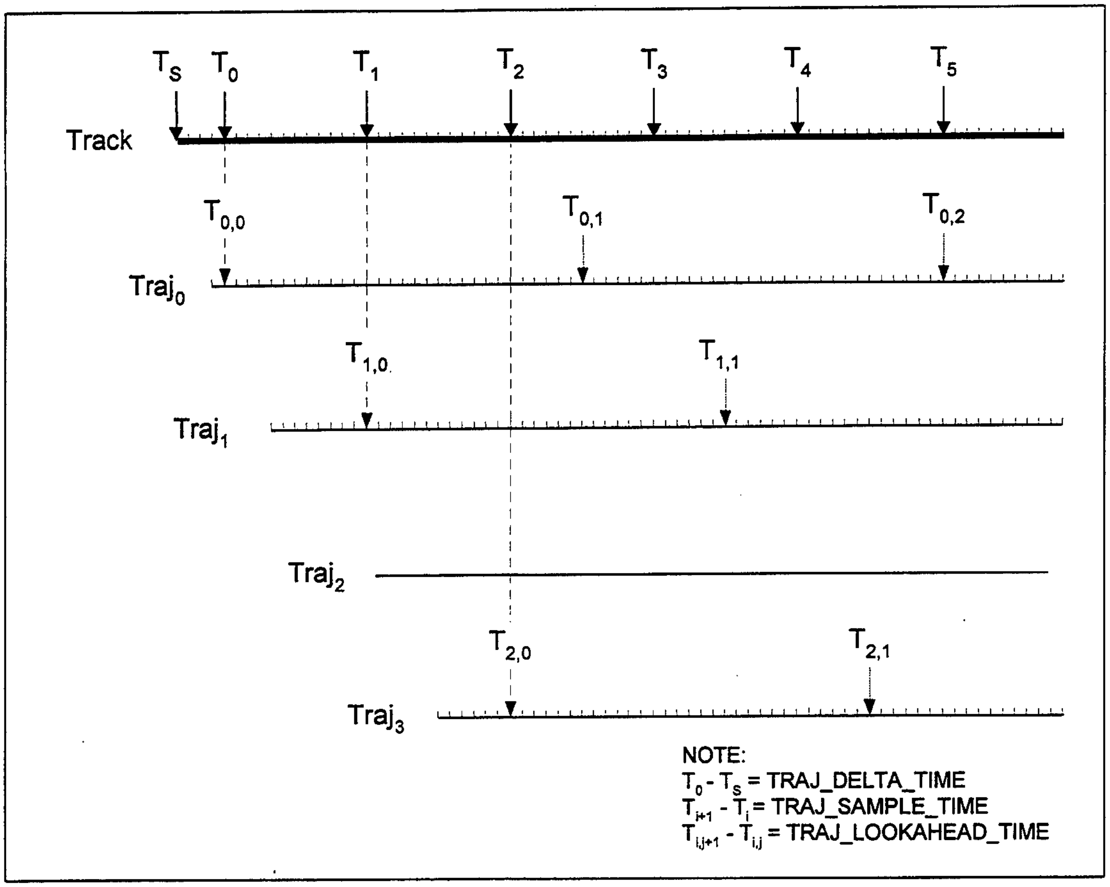

Figure 2.5-2: Interval Based Sampling

2.5.1.2 Estimation of the Metrics

Estimations of the error metrics (the horizontal, longitudinal, lateral, and vertical errors defined in Section 2.2.2) were calculated at a particular time point T as follows. Point A in Figure 2.5-3 represents the actual position of the aircraft at time T, point B represents the predicted position of the aircraft at time T along the trajectory and point C represents the next predicted position along the interpolated trajectory. Line segment AB represents the horizontal error. Point D is defined as the point along the line segment BC at which the angle formed by the line segments BD and DA is a right angle. Then the longitudinal error is represented by the directed line segment BD, and the lateral error is represented by the directed line segment DA.

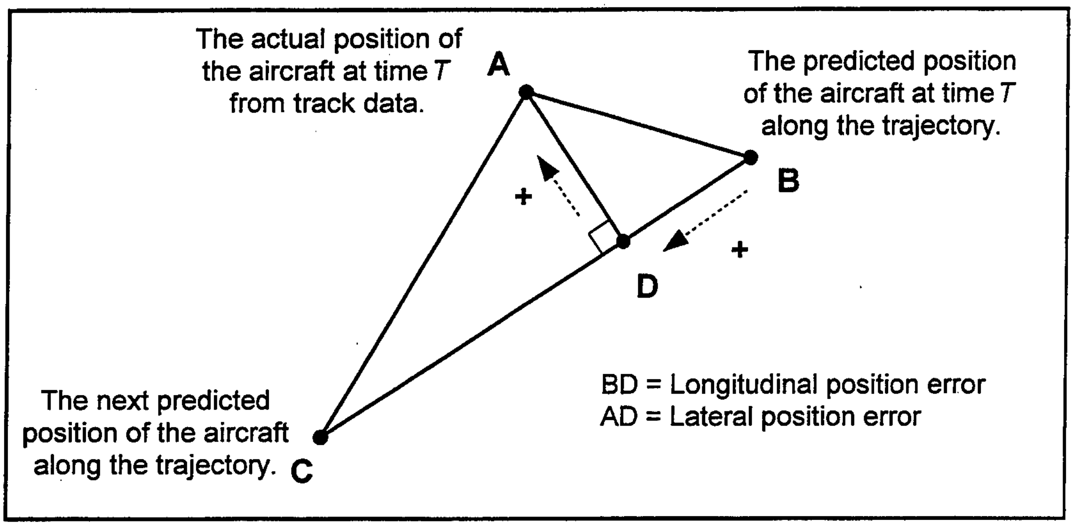

Figure 2.5-3: XY Error Geometry

The method used to calculate these errors is similar to the method used by the URET function GM_PTLINE (see Cale et. al., February 1997, section 3.4.16), described as follows:

As well as the normal case depicted in Figure 2.5-3, there are three special cases: (1) the line BC is parallel to the x-axis, (2) the line BC is parallel to the y-axis, and (3) the points B and C are identical.

If the coordinates of the point A are denoted as (x_A, y_A, z_A), the coordinates of the point B as (x_B, y_B, z_B) and the coordinates of the point C as (x_C, y_C, z_C), then:

1) Normal Case: The slope m of the line BC is then

$$m = \frac{(y_C - y_B)}{(x_C - x_B)}$$ **Equation 2.5-4**

The slope m' of the line through A perpendicular to BC is the negative reciprocal of m, that is

$$m' = -\frac{1}{m}$$ **Equation 2.5-5**

The equation of the line through the point A with the slope m' is

$$y = y_A + m'(x - x_A)$$ **Equation 2.5-6**

The equation of the line through the point B with the slope m is

$$y = y_B + m(x - x_B)$$ **Equation 2.5-7**

The point of intersection D, denoted as (x_D, y_D), is the simultaneous solution of these two equations:

$$x_D = \frac{y_B - y_A + m' x_A - m x_B}{m' - m}$$ **Equation 2.5-8**

$$y_D = \frac{m m' (x_B - x_A) + m y_A - m' y_B}{m - m'}$$ **Equation 2.5-9**

2) Special Case 1: BC is parallel to the x axis: This is true if and only if $y_B = y_C$. Then the equations for the coordinates of the point D are

$$x_D = x_A$$ **Equation 2.5-10**

and

$$y_D = y_B$$ **Equation 2.5-11**

3) Special Case 2: BC is parallel to the y axis: This is true if and only if $x_B = x_C$. Then the equations for the coordinates of the point D are

$$x_D = x_B$$ **Equation 2.5-12**

and

$$y_D = y_A$$ **Equation 2.5-13**

4) Special Case 3: Points B and C are identical: There is no solution. This case will not occur when the input data for this calculation is valid.

After the coordinates of D have been computed, the longitudinal and lateral errors can be calculated as follows:

The longitudinal error E_{long} is the length of the line BD, which is

$$E_{long} = \sqrt{(x_D - x_B)^2 + (y_D - y_B)^2}$$ **Equation 2.5-14**

The lateral error E_{lat} is the length of the line AD, which is

$$E_{lat} = \sqrt{(x_D - x_A)^2 + (y_D - y_A)^2}$$ **Equation 2.5-15**

The following process was used to determine the signs for the longitudinal and lateral errors. Referring again to Figure 2.5-3 the components of the vectors V_{BA} and V_{BC} are:

$$V_{BA} = \begin{bmatrix} x_A - x_B \\ y_A - y_B \\ z_A - z_B \end{bmatrix} = \begin{bmatrix} v_{BA_x} \\ v_{BA_y} \\ 0 \end{bmatrix} \qquad \textbf{Equation 2.5-16}$$

$$V_{BC} = \begin{bmatrix} x_C - x_B \\ y_C - y_B \\ z_C - z_B \end{bmatrix} = \begin{bmatrix} v_{BC_x} \\ v_{BC_y} \\ 0 \end{bmatrix} \qquad \textbf{Equation 2.5-17}$$

The scalar dot product of the vectors V_{BA} and V_{BC} is a scalar quantity, which can be calculated:

$$v_{BA_x} v_{BC_x} + v_{BA_y} v_{BC_y} \qquad \textbf{Equation 2.5-18}$$

The sign of the longitudinal error was considered positive if this scalar quantity was positive (i.e. track position ahead of trajectory predicted position).

The vector cross product of the vectors V_{BA} and V_{BC} has a single component in the z direction, which can be calculated:

$$v_{BA_x} v_{BC_y} - v_{BA_y} v_{BC_x} \qquad \textbf{Equation 2.5-19}$$

The sign of the lateral error was considered positive if the value of this component was positive (i.e. track position to the right of trajectory predicted position).

The vertical error E_{vert} is the signed difference between the altitudes (i.e., the z coordinates) of the two corresponding points from the interpolated track data and the interpolated trajectory data.

$$E_{vert} = z_A - z_B \qquad \textbf{Equation 2.5-20}$$

The vertical error is positive when the track position is above the trajectory predicted position.

2.5.2 Trajectory Report Generation

The Trajectory Report Generation (TRG) process is a UNIX shell script and a series of SQL/PL programs that generate several categories of reports, including:

1. Summary and overall statistics on all data including the track and trajectory data.
2. Statistics on the trajectory metrics. There are seven reports for look ahead times equal to zero, 300, 600, 900, 1200, 1500, and 1800 seconds, used in Sections 3.3.1 and 4.3.1.
3. Summary and overall descriptive statistics on the trajectory metrics data, excluding trajectories for which the EARLY_TRAJ_FLAG was set. The EARLY_TRAJ_FLAG flags a trajectory with a build time earlier than the first HCS track report.
4. Descriptive statistics on the trajectory metrics for the seven look ahead times, excluding trajectories for which the EARLY_TRAJ_FLAG was set.

5. A listing of ACID_CID, sample time, trajectory build time, lateral error, longitudinal error, horizontal error, vertical error, and track quality[1] for each look ahead time. This data was used for inferential statistical analysis.
6. Descriptive statistics for the trajectory metrics for each of the seven look ahead times for the horizontal phase of flight including straight and turning, used in Sections 3.3.3 and 4.3.3.
7. Descriptive statistics for the trajectory metrics for each of the seven look ahead times for the vertical phase of flight including level, ascending, and descending, used in Sections 3.3.4 and 4.3.4.
8. Descriptive statistics for the trajectory metrics for each of the seven look ahead times for the following four flight type cases:
   - Overflights
   - Departures
   - Arrivals
   - Internals

   This TRG report was used in Sections 3.3.2 and 4.3.2.
9. Descriptive statistics for the trajectory metrics for each of the given look ahead times for the top ten occurring aircraft types listed in Sections 3.1.5 and 4.1.5 for URET and CTAS, respectively. The use of this TRG report will be left for future studies.
10. Descriptive statistics for the trajectory metrics for each of the given look ahead times for general aviation airlines versus commercial airlines. The use of this TRG report will be left for future studies.

Note: All reports repeated with samples only above 18,000 feet.

2.6 Analysis Methodology

A statistical analysis of the trajectory accuracy of URET and CTAS was conducted. The results of these analyses are presented in Section 3.3 for URET and Section 4.3 for CTAS. The analyses consist of aggregate performance information, such as the number of samples and trajectories analyzed; context related statistics, such as the percentage of flights modeled; and actual trajectory accuracy statistics. For the trajectory accuracy statistics, the analysis is presented in tables delineating the results of inferential statistical tests performed and plots of the mean errors partitioned by selected factors, including look ahead time, phase of flight, and flight type. In addition, complete descriptive statistics for both analyses are contained in Appendices A and B. The following subsections provided additional information on each type of analysis that was conducted.

2.6.1 Aggregate Trajectory Performance Analysis

For the aggregate performance information, counts are reported for the total number of trajectories built, the number of trajectories sampled, and the number of flights processed. The duration of the trajectories and duration of each trajectory analyzed also provide the reader with the magnitude of the analysis coverage. Other aggregate performance information includes the total number of sample points used in the study.

2.6.2 Context Related Trajectory Performance Analysis

The context related statistics provide the reader with knowledge about the scope of the results, including the percentage of valid flights sampled, sampled trajectory age, and ratio of prediction coverage.

[1] Track quality is the percentage of track position reports which have been altered by the RDTRACKS processing.

2.6.2.1 Percentage of Valid Flights Sampled

The first, and probably most important, of the context related statistics is the percentage of valid flights sampled. Two conditions or events were required for a flight to be analyzed: it had to have both flight plan information from the HCS and trajectory prediction data from the DST. Referring to Figure 2.6-1, area "a" defines the valid aircraft flights for analysis. To be valid, an aircraft flight must have (1) a HCS flight plan message, (2) a set of HCS track position reports that have been verified by the RDTRACKS program discussed in Section 2.4.3, and (3) trajectory predictions from the DST. For the events under area "a" in Figure 2.6-1, some time overlap exists between the trajectory prediction and the track position reports. The area "c" includes valid aircraft flights with all the required HCS position data but insufficient trajectory prediction data (i.e., either no trajectory at all or not overlapping in time with the track data). The area "b" in Figure 2.6-1 includes the trajectories built without valid aircraft data, defined as lacking at least one of the HCS data defined above (i.e. flight plan, track data, time overlap, and positional verification).

It is important to quantify these events, since the analysis is based only on area "a". A DST's own bias in building trajectories can influence the trajectory accuracy statistics. In other words, the results are based only on situations when the DST chose to build a trajectory and obviously not on situations where it did not for whatever reason. Therefore, it is important to interpret the trajectory results in context of the trajectories it built. Referring to Figure 2.6-1, the ratio of area "a" to the sum of areas "a" and "c" defines the DST's fraction of valid flights with sampled trajectory prediction. It is reported as the percentage of the valid aircraft flights that have sampled trajectory prediction.

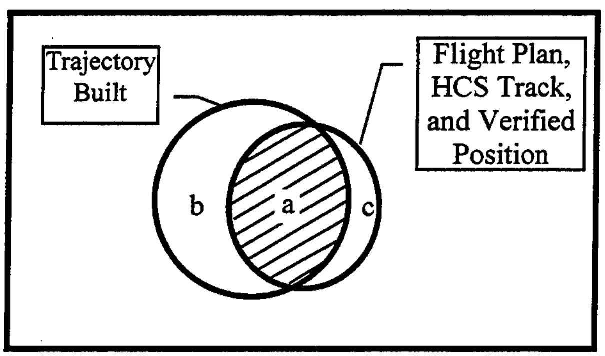

Figure 2.6-1: Trajectory and Aircraft Flight Events Venn Diagram

2.6.2.2 Ratio of Prediction Coverage

Another statistic useful in setting the context of the study estimates the trajectory prediction coverage over the track time analyzed. It is possible for trajectories to exist for a short prediction time with high accuracy while another DST could make predictions for the entire length of HCS track reports with less accuracy. This statistic quantifies this situation. It is defined as the ratio of the total time that the trajectories were predicted and captured for the analysis over the total time that the track was captured for analysis.

Referring to Equation 2.6-1, the trajectory prediction coverage is measured by taking each aircraft in area "a" in Figure 2.6-1 and calculating the difference between its last sampled trajectory's end time and its first sampled trajectory's start time. This difference is then divided by the difference between the end time of its last track report analyzed and the start time of its first track report.

This value will always be less than one, since trajectories are sampled and analyzed starting at 40 seconds past the beginning of the track start time and end with the shorter of the two, either track or trajectory. If a trajectory ends before the track end time, the ratio will be increasingly smaller than one, and if the track ends earlier the ratio will reach a maximum close to one due to the initial 40 seconds delay in sampling.

Equation 2.6—1

$$\text{ratio of prediction coverage} = \frac{(\text{last trajectory's end time - first trajectory's start time})}{(\text{track end time - track start time})}$$

For this analysis, the average and standard deviation of the ratio of prediction coverage is reported, as well as a 95 percent confidence interval around the sample mean. Also a histogram and quantile table (i.e. a table listing the percentiles from 0 to 100) are presented.

2.6.2.3 Sampled Trajectory Age

Another descriptive value that defines the context of the analysis is the age of the trajectory at the look ahead time of zero. Referring to the sampling process defined in Section 2.5.1, the longer a DST retains a trajectory, the older the age of the trajectory at each sampling interval. The age of the trajectory at each sample time is proportional to the frequency trajectories are rebuilt by the DST. In general, a DST that builds trajectories more frequently will have a smaller average trajectory age. Although there may be a correlation between trajectory age and trajectory prediction accuracy, it is also effected by the reasons for the refresh, as well as other factors.

2.6.3 Trajectory Accuracy Analysis

Basic descriptive statistics were calculated for each of the trajectory metrics. These statistics include the average, standard deviation, and maximum and minimum values, for: horizontal error, lateral error, absolute value of lateral error, longitudinal error, absolute value of longitudinal error, vertical error, and absolute value of vertical error. These descriptive statistics are reported for each look ahead time as well as several identified factors. Inferential statistics were used to determine whether the levels of the identified factors were statistically different and had a significant effect on each performance value. For example, at a look ahead time of zero, the hypothesis is tested on whether the mean horizontal error is equivalent in a turn or a straight path. This approach was chosen because of the application of the Central Limit Theorem (CLT), which allows the approximation of a Normal Distribution on a sample mean with a sufficiently large sample size (Devore, 1987). In this study, the sample sizes ranged in the thousands.

For the inferential statistics, three statistical tests were performed[2]:

1. Levene Test which determines if the particular performance value's (e.g. horizontal error) variances are significantly different statistically between the levels (i.e. by look ahead time, different flight types or phases of flight) (Neter, 1996)
2. Welch Test which determines if the particular performance value's sample means are significantly different statistically between the levels (Kelton and Law, 1991)

[2] The three statistical tests defined, Levene, Welch, and Tukey-Kramer, are described in more detail in Appendix A.0. Descriptions of the histograms, box plots, and mean comparison plots (i.e. diamond and circle plots) are also presented in Appendix A.0.

3. Tukey-Kramer Test which determines which of the particular pair or pairs of performance value's sample means are significantly different statistically between the levels (SAS Institute, 1995)

There are many factors which can affect the accuracy of the predictions of the flight path. Section 2.2.3 identifies the factors used in this report; other factors can be analyzed in the future if resources permit.

Table 2.6-1 lists the types of statistical analyses that were performed on each of the identified factors. The analyses included descriptive statistics (tables are presented in Appendix A), or inferential statistics in which hypothesis testing of the means and variances were performed (presented in both Appendix A and summarized in the Sections 3.3 and 4.3 for URET and CTAS, respectively). For several of the factors, both descriptive and inferential statistical analysis was performed. Table 2.6-1 also identifies whether graphical information is presented. Inferential statistics and graphical plots (i.e. histograms and quantile tables) were calculated for a subset of the available look ahead times, including zero, 600, 1200, and 1800 seconds (presented in Appendix A). Also, the Sample Mean Plots are presented in Sections 3.3 and 4.3 for URET and CTAS, respectively, and Sample Standard Deviation Plots are presented in Appendix B. The signed values of the error metrics (e.g. average lateral error) were used for these more exhaustive inferential techniques, since the sample mean acts as a measure of the bias of the trajectory predictions and the standard deviation as a measure of the uncertainty. The absolute value statistics (e.g. average absolute value of lateral error), which are also a useful measure of the uncertainty, have been included in the descriptive statistics reported in Appendix A.

Since the DSTs examined were designed to model IFR aircraft in en route airspace, this study needed a method to generically separate aircraft tracked by the HCS that may have been handed off and were entering a terminal airspace, from other strictly en route flights. The approximate method chosen was to perform two studies, one for all aircraft tracks captured by the HCS and a second performed on HCS track reports above 18,000 feet, which is well above all terminal airspace in the Center's under study. Therefore, all factors including look ahead time were analyzed twice: once with all the sampled track points and then with only sampled track reports above 18,000 feet.

Table 2.6-1: Analysis Summary

Factor For Samples at All Altitudes / Above FL180	Descriptive Statistics	Inferential Statistics	Sample Mean / Std. Dev. Plots	Histograms / Quantiles
Look Ahead Time	Yes	Yes	Yes	Yes
Flight Type	Yes	Yes	Yes	No
Phase of Flight Horizontal	Yes	Yes	Yes	No
Phase of Flight Vertical	Yes	Yes	Yes	No

3. URET Study Results and Observations

The results and observations presented in this section are based on the analysis of over seven hours of data recorded at the Indianapolis ARTCC (ZID). Specific information describing the scenario is presented in Section 3.1. Section 3.2 provides detailed information about one aircraft flight in the study which demonstrates the study's methodology, and Section 3.3 presents the results of the application of the trajectory accuracy metrics to URET.

3.1 Scenario Description

Figure 3.1-1 provides a data flow diagram logically describing the data files and processes used to obtain the flight plan, track, and trajectory data used for the URET analysis. For this study, data was collected from the URET installation at ZID. The source of the data was a Monitor Test and Recording (MTR) file, created at the output of the General Purpose Output Interface Module (GIM), containing the HCS flight plans, flight plan amendments, and track messages sent to URET over a 7.5 hour period on February 27, 1998. The weather data for the same time period was also recorded.

The scenario file, identified as *sn022798.dat* in Figure 3.1-1, was created using the MITRE/CAASD Reverse Host Converge/Merge Process (RHCMP) program (Byrdsong et. al., 1997). The *sn022798.dat* file is an ASCII file containing event records, which are primarily the NAS Host computer messages. These event records contain the time of the event, the event type, the aircraft identifier, and the aircraft's computer identifier followed by the event subfield. The format of these records is defined in Lindsay, 1998. This *sn022798.dat* file was then used as input to both the Flight Plan and Track Data Processing described in Section 2.4, and to URET D3A (specifically, URET Release D3A_R3_P2) in the WJHTC TFM laboratory.

The trajectory information was recorded by URET's Data Recorder program in binary format. The trajectory data is first parsed into a large ASCII file by MITRE's Data Collection Post Processor, DCPP, (Byrdsong et. al., 1997). This file, *ssg_file,* still needs to be parsed further and converted to a generic format. The *ssg_file* is input into a program composed of a UNIX shell script and C++ program called *up_scr.* This program parses the trajectory data into a generic ASCII file called *traj_file.dat*, which was input to the Trajectory Data Processing described in Section 2.5. The formats of the *ssg_file* and the *traj_file.dat* files are described in WJHTC/ACT-250, 1999.

Tables 3.1-1 and 3.1-2 summarize the characteristics of the airspace and the aircraft flights through the airspace, respectively, for the subject scenario.

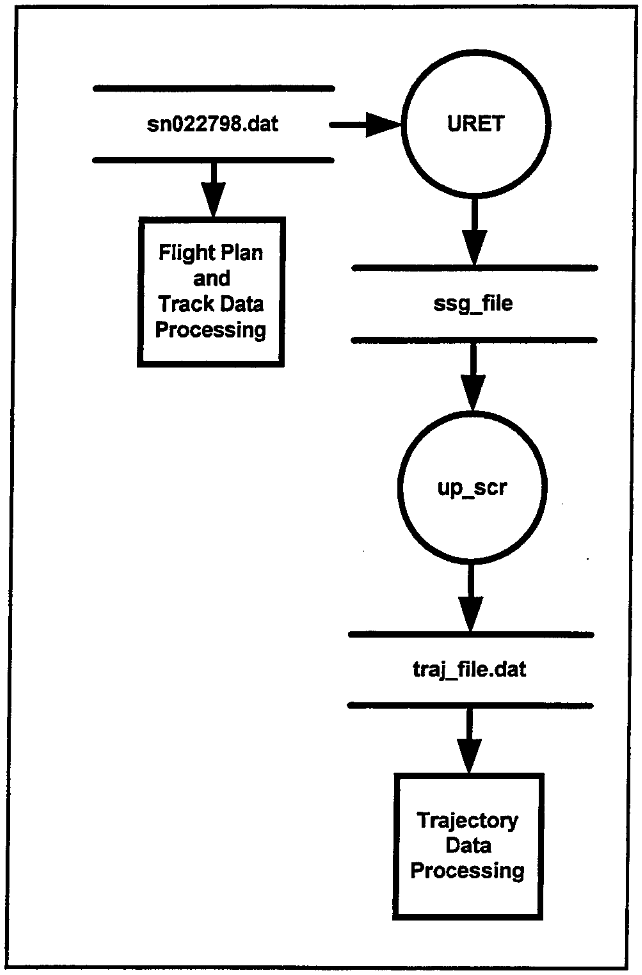

Figure 3.1-1: URET Data Sources

3.1.1 Airspace Definition

Table 3.1-1 summarizes the spatial and time boundaries of the ZID data sample used.

Table 3.1-1: ZID Airspace Definition for URET Study

Airspace	Indianapolis Center (ZID)
Altitude	0 to 60,000 feet
Horizontal boundaries	Defined by the high altitude sectors
Date	February 27, 1998
Start time	12:01:31 UTC (6:01 a.m. local time)
End time	19:33:10 UTC (1:33 p.m. local time)
Duration	07:31:39 or 27,099 seconds

3.1.2 Aircraft Counts

Table 3.1-2 delineates the counts of aircraft flights in the sample of air traffic analyzed.

Table 3.1-2: Aircraft Counts for URET Study

Total number in sample (IFR)	2656
Number excluded	150 (5.65 %)
Number processed	2506 (94.4 % of total)
Number of airliners	1913
Number of General Aviation aircraft	593
Number of jets in the top 20 aircraft	15
Number of turboprops in the top 20 aircraft	5
Number of piston aircraft	0
Average length of track	34.7 minutes, 2082 seconds, or 174 position reports
Number of overflights	1115 (44.5 %)
Number of departures	692 (27.6 %)
Number of arrivals	630 (25.1 %)
Number of internal flights	69 (2.8 %)

3.1.3 Excluded Flights

In measuring the accuracy of track predictions, the true positions of the aircraft are assumed to be the positions reported by the HCS. For some aircraft, it is clear that the HCS reported positions are not correct. Track processing algorithms were used to correct the position data where possible, as described in Section 2.4. When it was not possible to correct the data, the individual tracks and in some cases entire flights were deleted from the scenario being examined, as discussed in the following sections. Statistics were collected on an aircraft flight only if both a track and a set of predicted trajectories were available. For this analysis of URET, there were three categories of excluded aircraft totaling 150 flights that were deleted from the original set of 2656 IFR flights (a reduction of 5.65 %).

3.1.3.1 Military Flights

Since it is often not possible from flight plan data to accurately predict the flight paths of military flights, which usually are doing either gunnery practice or aerial re-fueling maneuvers, military flights were excluded from the analysis. This was done by selecting out all of the flights which had a call sign containing more than three leading alphabetic characters (e.g., ANVIL, CODER, RACER, SABER, STEEL). Although this is not an exact definition of military aircraft, it was considered to be sufficient for this study. 79 military flights were excluded.

3.1.3.2 Non-initialized Flights

As discussed in Section 2.4, sometimes the HCS processing algorithms are unable to establish a consistent track for the aircraft. There were 18 flights excluded for this reason.

3.1.3.3 Uncertain Position Flights

The processing of the HCS track data requires correcting some of the track reports which are clearly in error. For example, as discussed in Section 2.4.3, sometimes the same XY coordinates

are repeated even though the aircraft has moved between the radar reports. Now in some cases the corrected track reports are substantially different from the original aircraft positions reported by the HCS. This situation implies that we, the experimenters, do not know the true position of the aircraft. Flights having a corrected track position report substantially different from the original position report were deleted (53 of these flights were excluded).

3.1.4 Truncated Flights

Often in the HCS track reports, several tracks reports are missing or have bad data. The position of the aircraft during the gap is unknown. If the gap is short, the missing track reports can be interpolated. When a large gap in the track data occurs, the track positions after the gap are discarded. Of the 452,976 radar track position reports, 15,756 or 3.6 % were discarded by truncating the tracks after missing or bad data.

Measurements of trajectory prediction errors were made on aircraft either already in the ZID airspace or approaching the ZID airspace and about to be in the airspace. Measurements were not made on aircraft after they left ZID airspace. That is, no measurements were made on the portions of the tracks outside ZID when the aircraft were flying away from the ZID airspace. 17.2% of the interpolated track reports were not used for this reason.

3.1.5 Aircraft Mix

The majority of the aircraft analyzed in this study are commercial airliners. The top 10 aircraft type account for 1358 of the 2506 flights, or 54.2 % of the total; the top 20 aircraft account for 1746 of the 2506 flights, or 69.7 % of the total. A histogram depicting the frequency of occurrence of the top 20 aircraft is provided in Figure 3.1-2. The aircraft are identified by their FAA type designators. Of the top 20 aircraft, 15 are jets and five are turboprops. Table 3.1-3 lists the aircraft manufacturers and model names of the top 10 aircraft. All of the top 10 aircraft are jets except for the EMB 120.

Table 3.1-3: URET Scenario Aircraft

RANK	FAA TYPE IDENTIFIER	MANUFACTURER / MODEL	NUMBER OF FLIGHTS	PERCENTAGE OF FLIGHTS
1	DC9	McDonnell-Douglas DC9	224	8.94 %
2	B727	Boeing 727	186	7.42 %
3	B73B	Boeing 737-300/400/500	182	7.26 %
4	CARJ	Canadair Bombardier Regional Jet	152	6.07 %
5	B757	Boeing 757	143	5.71 %
6	MD80	McDonnell- Douglas MD80	131	5.23 %
7	MD88	McDonnell-Douglas MD88	122	4.87 %
8	B73A	Boeing 737-200	87	3.47 %
9	E120	Embraer EMB 120	78	3.11 %
10	B737	Boeing 737-200	53	2.11 %

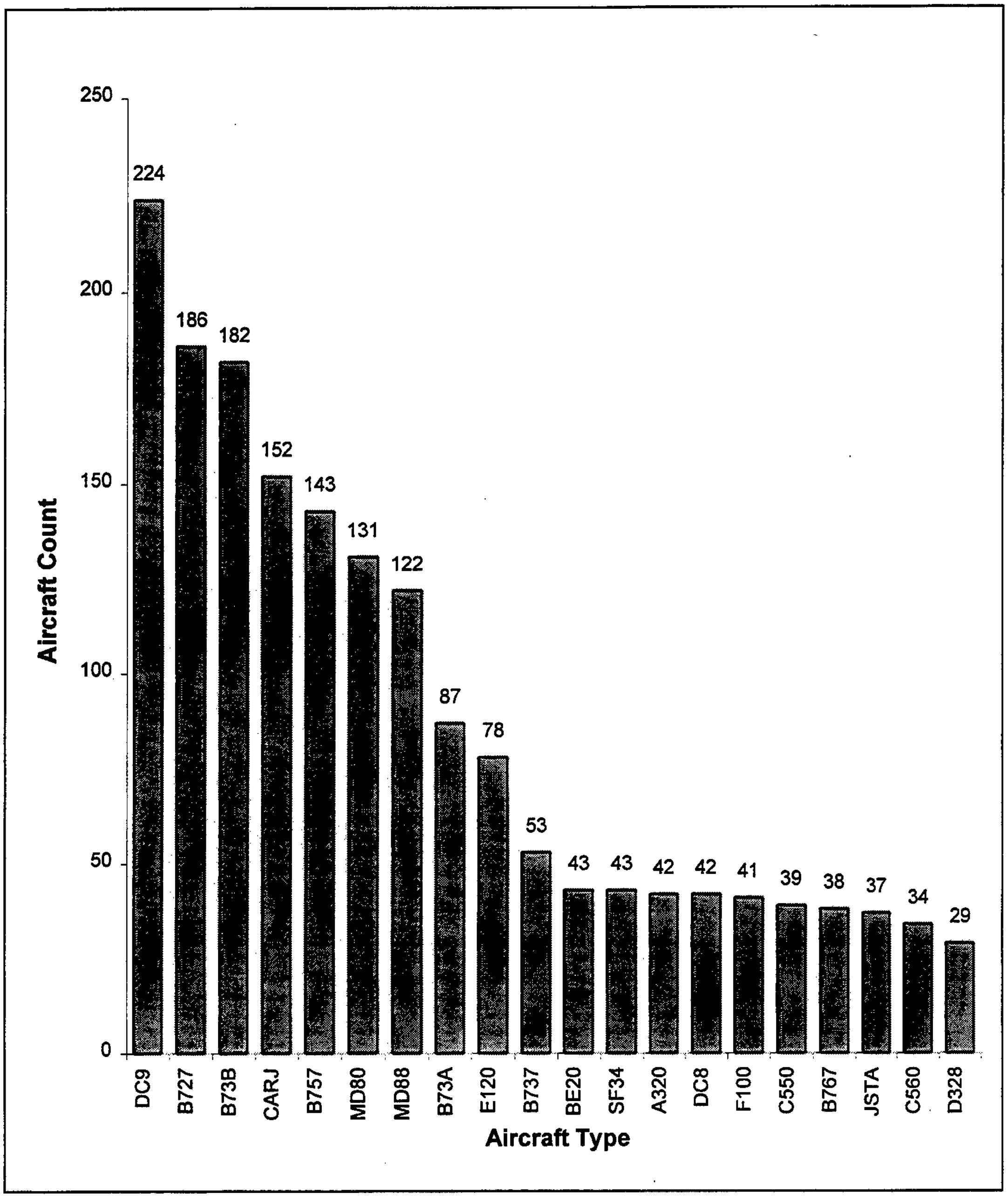

Figure 3.1-2: Top 20 Aircraft Frequency Histogram - ZID Data

3.2 Observations

This section presents observations made during analysis of the data, which provide detailed information about a specific aircraft flight in the URET study. These observations are included before the results so that the reader can better understand the methodology, and therefore better understand the statistics and data presented in Section 3.3. While each observation details a typical flight, the errors are not necessarily representative of common occurrences. Appendix C provides additional anomalous flights, which were selected to verify the methodology and to examine trajectory accuracy errors with URET.

3.2.1 URET1

In this example, a Boeing 737 commercial airliner departed Baltimore-Washington International (BWI) enroute for Chicago's Midway Airport (MDW). The filed route was J149 and the filed altitude was flight level (FL) 350. This route was an overflight through the northeast part of the ZID airspace. The filed route from BWI to MDW is shown in Figure 3.2-1 with selected waypoints illustrated as small circles.

3.2.1.1 Track Data

The HCS acquired the radar track while the aircraft was in West Virginia (Washington Center, ZDC) on J149 heading west towards ZID. The HCS tracked the aircraft until it left ZID and entered the Chicago Center (ZAU) airspace heading towards Fort Wayne (FWA) on J149. The track data extends all the way to the Goshen VORTAC (GSH); however, no trajectory accuracy measurements were made after the aircraft left the ZID airspace. The track is shown in Figure 3.2-1. The track and the Flight Plan route are coincident.

The aircraft followed its filed route and filed altitude until a flight amendment was submitted to descend the aircraft from FL 350 to FL 310. After the amendment was submitted, there was an altitude hold at FL 350 for about a minute. Then the aircraft was cleared to the interim altitude of FL 330. The aircraft paused briefly at FL 330, and then, after being cleared, continued down to FL 310. The aircraft exited the ZID airspace at FL 310. Its Top of Descent (TOD) from FL 310 was outside of ZID. The altitude profile is shown in Figure 3.2-2.

The radar position reports supplied by HCS were reasonably consistent. Of the 244 position reports, 10 were defective and had to be fixed. The first track report had zero altitude and was discarded. There were five stationary position reports, which repeated the previous position report. The XYZ coordinates for these reports were replaced by interpolated values. There were four position reports which had zero altitude and one position report which was both stationary and had zero altitude. These reports were replaced by interpolated values as well.

3.2.1.2 Trajectory Data

The track time and the time lines for the eight trajectories recovered for this aircraft are presented in Figure 3.2-3. The time line for the track is labeled "Track." The time lines for the trajectories are labeled with the trajectory's build time. The first three of these trajectories (the 45728, 45729, and 47218 trajectories) were built before the first track point at time 47230. The sample points for calculating the trajectory accuracy metrics are shown by arrows drawn from the track time line to the latest trajectory available at that sample time. The first sample time was 47270 (40 seconds after the first track point). This sample used the 47230 trajectory which was built with the first track point. Of these eight trajectories three were sampled: the 47230, 49062, and 49194 trajectories.

The three trajectories have been plotted in Figures 3.2-1 and 3.2-2. In the plan view (Figure 3.2-1), it can be seen that the trajectories are coincident with the filed route when the aircraft is approaching and within the ZID airspace. In the altitude profile plot (Figure 3.2-2), it can be seen that the trajectories differ from the track data near the TOD.

The trajectories plotted all start with a data point, which is sampled for the error measurements. Previous trajectory points have been discarded because they are not needed for the metric calculations. Up to two minutes of initial trajectory data may be discarded. For example, the first data point plotted for Trajectory 3 is at 49,310 seconds, although the trajectory was built at 49,194 seconds.

3.2.1.3 Metrics

Table 3.2-1 presents the trajectory metrics calculated for this aircraft. The longitudinal and lateral errors are in nautical miles; the vertical errors are in feet. As discussed in Section 2.5.1, a sample is taken 40 seconds after the start of track and then repeated each two minutes until either the track ends, the trajectory ends, or the track leaves the center. At each sample time, the distance between the track and trajectory was calculated at the current time and at look ahead times of 5, 10, 15, 20, and 30 minutes into the future. That is, measurements were made at look ahead times of 0, 300, 600, 900, 1200, 1500, and 1800 seconds. The metrics were not computed after time 49430 because the aircraft departed the ZID airspace at 49,550 seconds. The data in the table shows that both the longitudinal and lateral errors were small even at the higher look ahead times. The plot of the track and trajectory data in Figure 3.2-1 shows that the lateral errors are negligible. (The plot does not show the longitudinal errors.)

The vertical profile plot in Figure 3.2-2 shows that near the TOD there are differences in altitude between the predicted trajectories and the actual track flown. The first trajectory predicts an initial TOD at a time of 49,350 seconds and an initial Bottom of Descent (BOD) at an altitude of 31,000 feet and a time of 49,500 seconds. The actual (track) initial TOD was at 49,080 and the actual (track) initial BOD was at 49,370. The predicted TOD was updated to 49,100 by the second predicted trajectory when a Flight Plan Amendment was received. The second trajectory descended the aircraft to an interim altitude of 33,000 feet, held it there for four minutes, and then descended it to 31,000 feet starting at 49,420 reaching 31,000 feet at 49,500, and then it had a final descent, leaving 31,000 at 49,910. The track did not hold at 33,000 feet. The plot of the third trajectory flies the aircraft at 31,000 feet, coincident with the track, passing out of the ZID airspace before descending.

The inaccurate predictions of the TOD and the interim altitude hold produce errors in the predicted altitudes. Error measurements are made every 60 seconds (for some look ahead time). Measurements made at 49,190, 49,250, 49,310, 49,370, and 49,430 seconds show large altitude errors. All of the large altitude prediction errors except one are based on Trajectory 1. The other large altitude error is based on Trajectory 2. The errors have been listed in Table 3.2-1. The time of measurement is the sum of the sample time and the look ahead time. Figure 3.2-2 shows the differences in altitude between the track data and the predicted trajectories which produce these altitude errors.

The largest error (3629 feet) occurred at 49,370 when the aircraft had leveled off at 31,000 feet and it had been predicted to be just past its initial TOD, descending from 35,000 feet. This measurement was made for a look ahead of 15 minutes.

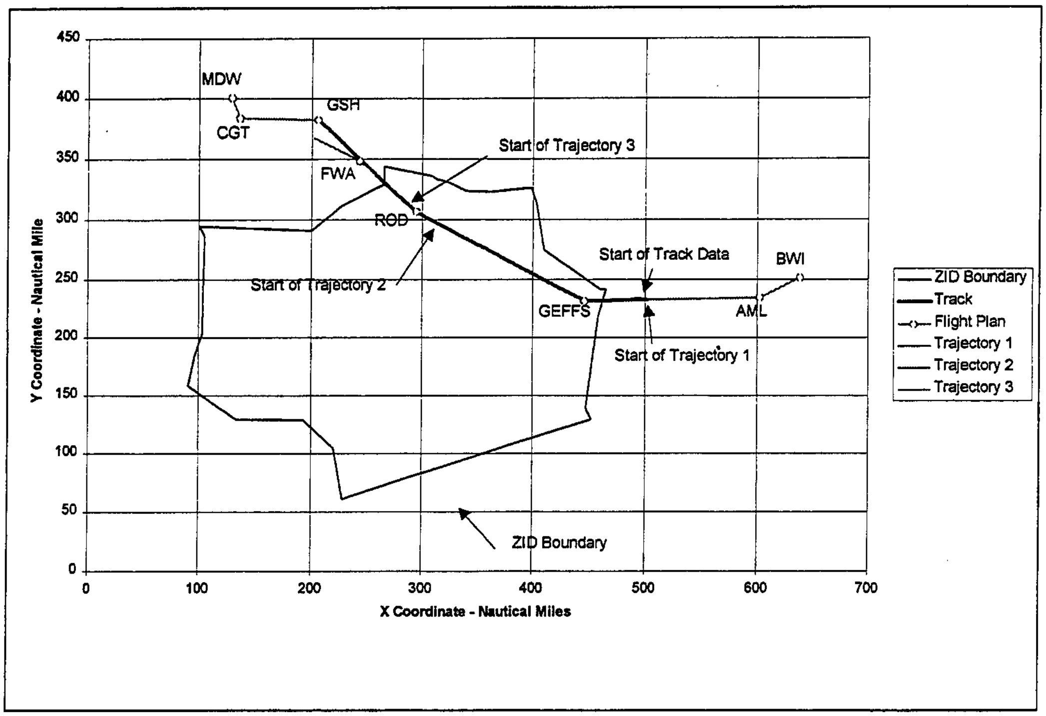

Figure 3.2-1: Aircraft Track and Route

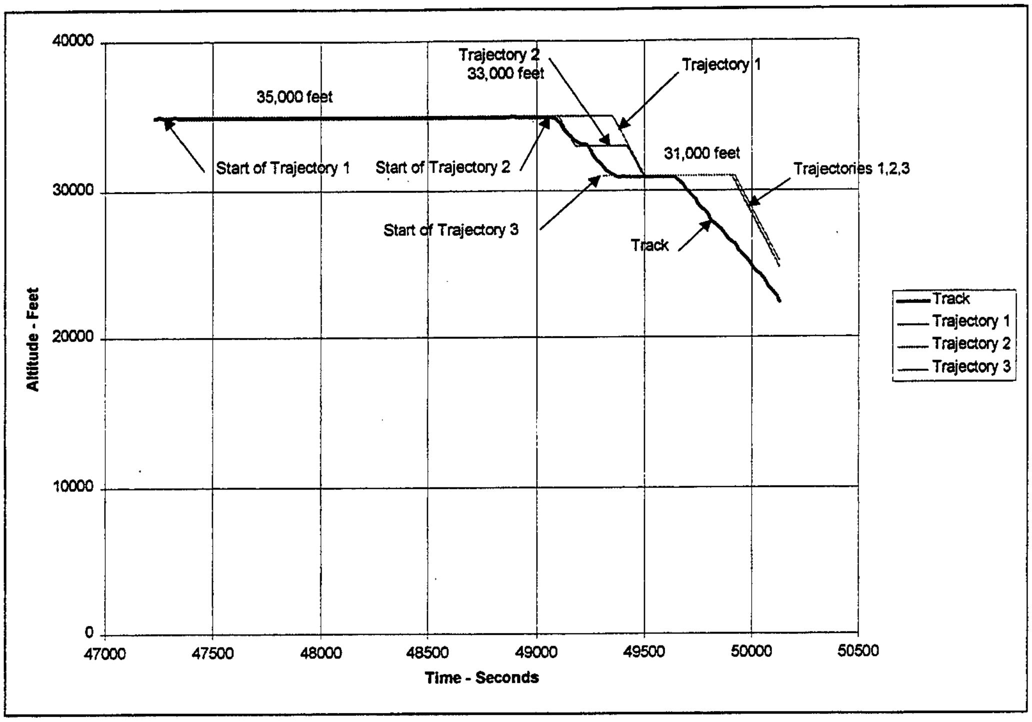

Figure 3.2-2: Altitude Vs. Time

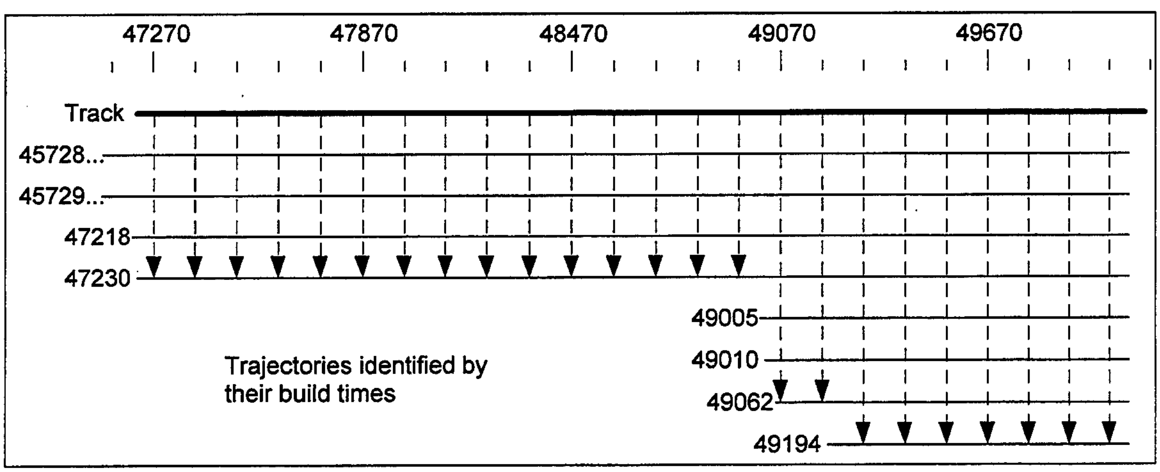

Figure 3.2-3: Sampled Trajectories

Table 3.2-1: Trajectory Metrics (1 of 2)[3]

Sample Time	Traj No	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
47270	1	47230	0	-0.23	-1.63	-100.00
			300	-0.50	-0.12	-100.00
			600	-0.71	0.13	-100.00
			900	-0.85	0.18	-100.00
			1200	-0.60	0.21	-100.00
			1500	-1.16	-0.09	-100.00
			1800	-0.52	-0.25	-100.00
47390	1	47230	0	-0.38	-0.42	-100.00
			300	-0.67	-0.05	-100.00
			600	-0.81	0.09	-100.00
			900	-0.92	0.22	-100.00
			1200	-0.52	0.26	-100.00
			1500	-0.49	-0.23	-33.00
			1800	-0.16	-0.35	-1733.00
47510	1	47230	0	-0.46	-0.11	-100.00
			300	-0.62	0.24	-100.00
			600	-0.90	0.14	-100.00
			900	-0.13	0.36	-100.00
			1200	-0.81	-0.03	-100.00
			1500	-0.55	-0.09	-100.00
			1800	0.54	-0.14	-3400.00
47630	1	47230	0	-0.56	-0.09	-100.00
			300	-0.66	0.07	-100.00
			600	-0.91	0.12	-100.00
			900	-0.55	0.30	-100.00
			1200	-1.08	-0.19	-100.00
			1500	-0.39	-0.28	-956.00
			1800	1.03	-0.27	-2061.60
47750	1	47230	0	-0.70	0.12	-100.00
			300	-0.84	0.16	-100.00
			600	-0.85	0.11	-100.00
			900	-0.54	0.13	-100.00
			1200	-0.44	-0.20	-100.00
			1500	-0.41	-0.39	-2300.00
47870	1	47230	0	-0.71	0.13	-100.00
			300	-0.85	0.18	-100.00
			600	-0.60	0.21	-100.00
			900	-1.16	-0.09	-100.00
			1200	-0.52	-0.25	-100.00
			1500	0.74	-0.20	-3629.08
47990	1	47230	0	-0.81	0.09	-100.00
			300	-0.92	0.22	-100.00
			600	-0.52	0.26	-100.00
			900	-0.49	-0.23	-33.00
			1200	-0.16	-0.35	-1733.00
			1500	1.27	-0.10	-400.57

[3] In this chart, longitudinal and lateral error are reported in hundredths of nautical miles, and the vertical error is reported in hundredths of feet. The precision of the input HCS altitude data is reported to the nearest 100 feet, the apparent difference is simply an artifact of the track report processing.

Table 3.2-1: Trajectory Metrics (2 of 2)

Sample Time	Traj No	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
48110	1	47230	0	-0.90	0.14	-100.00
			300	-0.13	0.36	-100.00
			600	-0.81	-0.03	-100.00
			900	-0.55	-0.09	-100.00
			1200	0.54	-0.14	-3400.00
48230	1	47230	0	-0.91	0.12	-100.00
			300	-0.55	0.30	-100.00
			600	-1.08	-0.19	-100.00
			900	-0.39	-0.28	-956.00
			1200	1.03	-0.27	-2061.60
48350	1	47230	0	-0.85	0.11	-100.00
			300	-0.54	0.13	-100.00
			600	-0.44	-0.20	-100.00
			900	-0.41	-0.39	-2300.00
48470	1	47230	0	-0.60	0.21	-100.00
			300	-1.16	-0.09	-100.00
			600	-0.52	-0.25	-100.00
			900	0.74	-0.20	-3629.08
48590	1	47230	0	-0.52	0.26	-100.00
			300	-0.49	-0.23	-33.00
			600	-0.16	-0.35	-1733.00
			900	1.27	-0.10	-400.57
48710	1	47230	0	-0.81	-0.03	-100.00
			300	-0.55	-0.09	-100.00
			600	0.54	-0.14	-3400.00
48830	1	47230	0	-1.08	-0.19	-100.00
			300	-0.39	-0.28	-956.00
			600	1.03	-0.27	-2061.60
48950	1	47230	0	-0.44	-0.20	-100.00
			300	-0.41	-0.39	-2300.00
49070	2	49062	0	-0.44	-0.25	-100.00
			300	0.09	-0.20	-2033.00
49190	2	49062	0	-0.33	-0.35	267.00
			300	0.49	-0.10	-238.11
49310	3	49194	0	0.05	-0.14	600.00
49430	3	49194	0	0.51	-0.27	-100.00

3.3 Results

After running URET Delivery 3A with the 7.5 hour scenario file described in Section 3.1, a total of 16,631 trajectories were sampled out of 40,894 trajectories. The sampled trajectories were from 2436 flights. Therefore, each one of these flights on average had 6.8 trajectories analyzed. The average duration of these trajectories is 57 minutes with standard deviation of 39 minutes. The sampling process reduced the trajectory to the portion where both HCS track data and the predicted trajectory overlap in time, so the duration of the trajectory actually analyzed was reduced to approximately 29 minutes on average, with a standard deviation of 18 minutes.

To set the context of the study as defined in Section 2.6.2.1, the counts of the event areas illustrated in Figure 2.6-1 are listed in Table 3.3-1 below. Referring to Figure 2.6-1, the ratio of area "a" to the sum of areas "a" and "c" defines URET's fraction of valid flights with sampled trajectory prediction. For URET, 97.2 percent of the valid aircraft flights had sampled trajectory prediction.

Table 3.3-1: Valid Track and Trajectory Counts for URET Scenario

	Valid HCS Flight Data	Insufficient Valid HCS Flight Data	Total Flights With Trajectories
Trajectory	2436 (a)	1296 (b)	3732 (a +b)
Insufficient Trajectory	70 (c)		
Total Valid Flights	2506 (a + c)		

As defined in Section 2.6.2.2, another statistic useful in setting the context of the study estimates the trajectory prediction coverage over the track time analyzed. For URET, each analyzed flight had an average of 96.6 percent of prediction coverage with a standard deviation of 6.1 percent. Referring to Figure 3.3-1 and the Quantiles in Table 3.3-2, the distribution decreases very sharply, making a narrow 95 percent confidence interval around the mean between 96.4 to 96.9. The maximum ratio of prediction coverage for URET was 99.4 percent and the minimum was 2.9 percent.

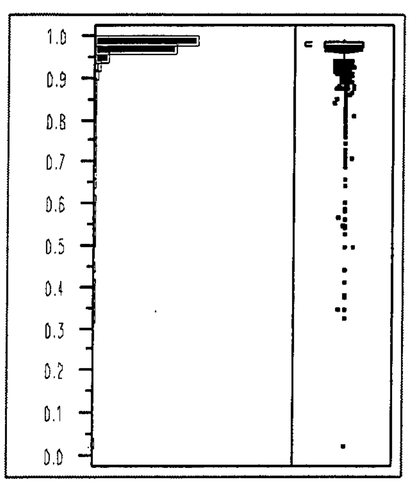

Figure 3.3-1: URET's Distribution of Ratio of Coverage Statistic

Table 3.3-2: Quantile Table of Ratio of Prediction Coverage

Quantile Label	Percentile	Value
maximum	100.00%	0.99434
	99.50%	0.99246
	97.50%	0.99024
	90.00%	0.98813
quartile	75.00%	0.98491
median	50.00%	0.97938
quartile	25.00%	0.97037
	10.00%	0.94964
	2.50%	0.84657
	0.50%	0.5
minimum	0.00%	0.02913

As described in Section 2.6.2.3, another descriptive value that defines the context of the analysis is the age of the trajectory at the look ahead time of zero. For URET, trajectories are built when the HCS track positions are outside thresholds (referred to as conformance boxes) around the trajectory centerline, when certain messages are received from the HCS, or every 20 minutes. This study's sampled URET trajectories have an average trajectory age of approximately four minutes with a standard deviation of 5.1 minutes.

As discussed above, URET builds trajectories every 20 minutes maximum and often earlier depending on the HCS track positions. The build time in seconds combined with the aircraft identifier string and HCS CID should uniquely represent a particular trajectory. However, there are instances that an aircraft has multiple trajectories with common build times. This is an anomaly of URET's data recording software, which runs in parallel to the URET processes but apparently has a lower priority on machine resources. The anomaly occurs when the data recorder builds up a queue in its processing and gets behind the data being stored in the URET databases. If more than one trajectory is in the queue for a particular flight, the time stamps of the trajectories utilized for the build time can get duplicated creating common trajectory build times. The solution applied was to add one second to the trajectory build time (i.e. sequentially by recording order) in these instances. For the scenario in this study, around 10 percent of the 40,894 URET trajectories needed this adjustment. Once again, the adjustment was only to the build time and was only changed by one second.

The actual trajectory metrics and sampling process is defined in Section 2.5.1. For this 7.5 hour ZID scenario, 138,532 samples were taken against the 16,631 trajectories discussed above. Each sample consisted of spatial prediction error measurements including horizontal error, lateral error, longitudinal error, and vertical error. These measures are reported as a function of different look ahead times from zero to 30 minutes in the future, so the trajectory prediction performance includes the spatial prediction errors partitioned by look ahead time. As a review, look ahead time is the predicted time into the future measured from the sample start time for that particular flight. In this study increments of five minutes were used up to a look ahead time of 30 minutes into the future. In other words, if the flight had both a sampled trajectory and sufficient HCS

track reports for the full range of time overlap, error measurements would be calculated at zero, five, 10, 15, 20, 25 and 30 minutes into the future.

Table 3.3-3 lists the types of statistical analyses that were performed on each of the identified factors. The analyses include either descriptive statistics in which simple tables are presented, inferential statistics in which hypothesis testing of the means and variances were performed, or both. This table also lists whether graphical information was presented with references to the appropriate section number. Inferential statistics and graphical plots (i.e. histograms and quantile tables) were calculated for a subset of the available look ahead times, including zero, 600, 1200, and 1800 seconds. The signed values of the error metrics (e.g. average lateral error) were used for these more exhaustive inferential techniques, since the sample mean acts as a measure of the bias of the trajectory predictions and the standard deviation as a measure of the uncertainty. The absolute value statistics (e.g. average absolute value of lateral error), which are also a useful measure of the uncertainty, have been included in the descriptive statistics reported in Appendix A.1.

Table 3.3-3: URET Analysis Summary

Factor For Samples at All Altitudes / Above FL180	Descriptive Statistics	Inferential Statistics	Histograms / Quantiles	Section Number
Look Ahead Time	Yes	Yes	Yes	3.3.1
Flight Type	Yes	Yes	No	3.3.2
Phase of Flight Horizontal	Yes	Yes	No	3.3.3
Phase of Flight Vertical	Yes	Yes	No	3.3.4

3.3.1 Analysis of Look ahead time on Trajectory Accuracy

The main factor analyzed in this study was look ahead time, defined in Section 2.2.3.3. One would expect look ahead time to have a statistically significant effect on performance, but the magnitude of the effect is also of interest. A complete table of the spatial prediction error statistics are presented at the look ahead times of zero, 300, 600, 900, 1200, 1500, and 1800 seconds (i.e. zero to 30 minutes) in Appendix A.1. The focus of the following analysis is on the signed error for lateral, longitudinal, horizontal, and vertical errors at the look ahead times of zero, 600, 1200, and 1800 seconds. This analysis includes an example set and summary results of several tables of statistical information provided by the SAS-JMP Software package (SAS Institute, 1995). They are used to evaluate the error data categorized by look ahead time and in the later sections by horizontal and vertical phase of flight. Complete tables for the URET data are provided in Appendix A.1. The tables present test results for unequal variance including the Levene Test and the Welch Anova Test. They also include a pairwise means comparison, referred to as the Tukey-Kramer Honestly Significant Difference (HSD) Test. Graphical plots present a comparison of means with a quantile box, a plot of the means at look ahead time versus error, and a plot of means using the Tukey-Kramer criteria.

3.3.1.1 Samples at all altitudes

The sample variance of the horizontal error from the four look ahead times are compared first by a Levene Statistical test (Neter, 1996). Referring to Table 3.3-4, this statistical test determines if the hypothesis of equal variances can be rejected. The hypothesis can be rejected in this case, since the variances are significantly different. From Table 3.3-4, the variance of horizontal error is increasing as the look ahead time increases.

Table 3.3-4: Tests for Equal Variances and Tests for Equal Means

Tests that the Variances are Equal (Horizontal Error)[4]				
Level (seconds)	Count	Std Dev (nm)	MeanAbsDif To Mean (nm)	MeanAbsDif To Median (nm)
0	35928	1.08	0.71	0.69
600	23964	5.47	3.66	3.36
1200	13836	8.89	5.82	5.39
1800	6444	10.90	7.01	6.49
Test	F Ratio	Deg of Freedom	DF Den	Prob>F
Levene	7382.12	3	80168	0.0000
Welch Anova testing Means Equal, allowing Std's Not Equal				
	F Ratio	Deg of Freedom	DF Den	Prob>F
	8172.26	3	18809	0.0000

Next, the sample mean for each look ahead time is compared. Referring to Table 3.3-4, the Welch test is applied which compares distributions with different variances and sample sizes. It tests whether all the group means are equal. For the horizontal error at different look ahead times, the Welch Test provides evidence to reject the hypothesis that these mean errors are equal. In Figure 3.3-2, diamonds are drawn around each mean representing the 95 percent confidence interval (in this case, the diamonds are flat and look more like heavy lines due to the large range between the group means). These confidence intervals show an increase in the average horizontal error from zero to 1800 seconds look ahead time of approximately 9.0 nautical miles, from 1.2 nautical miles to 10.2 nautical miles.

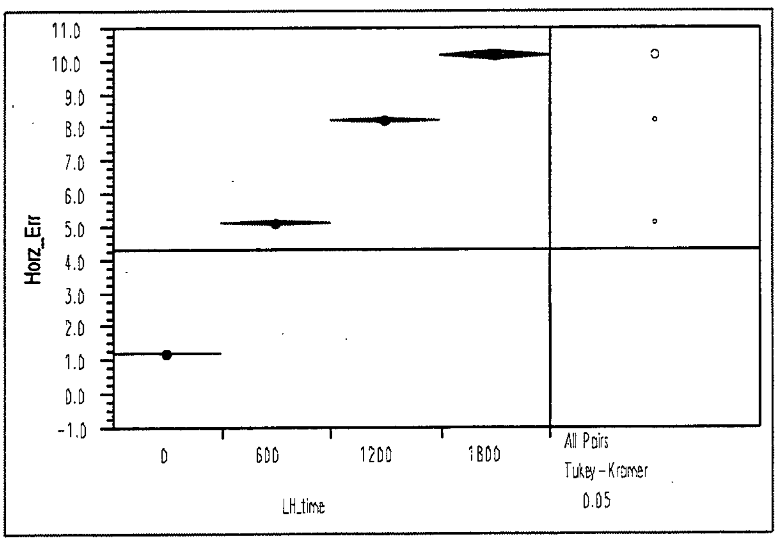

Figure 3.3-2: Sample Mean Comparison of Horizontal Error at Four Look Ahead Times[5]

[4] Mean Absolute difference to mean and median are intermediate calculations in the Levene Test described in Appendix A.0.

[5] Normally, the height of the diamond is the length of the confidence interval and the width is proportional to the sample size. In this study, the width has been set equal for all sample sizes.

The lower portion of Table 3.3-5 presents the results of a third statistical test, called the Tukey-Kramer Test, that compares all pairs of means and holds the Type I error at 0.05 for the entire test. It has the exact Type I error if the sample sizes are equal, and is conservative if they are not, which is the case in this study. The horizontal error at the four look ahead times is significantly different between all pairs. The Tukey-Kramer Test provides a distance referred to as the Least Significant Difference (LSD)[6] that can be subtracted from the absolute difference of each pair of means. If the result is positive, the absolute difference of the means is greater than LSD, and the pair of means is significantly different. If the result is negative, the LSD is greater, and the pair is not significantly different. The upper portion of Table 3.3-5 lists the pairwise differences of the sample means for the various look ahead times. All these pairwise comparisons of the means of the horizontal error at the different look ahead times were significant.

The right side of Figure 3.3-2 presents a graphical form of the Tukey-Kramer Test. Too small to be drawn in some cases, it constructs circles around the sample means with a diameter approximately equal to the 95 percent confidence interval. However, this interval is expanded to account for the comparison of all pairs. In short, if the circles overlap the means are not considered significantly different; if they do not overlap, the means are considered significantly different. The circles drawn in Figure 3.3-2 are not overlapping at all, illustrating the numerical results that all the means are different.

Table 3.3-5: Statistical Comparison of All Means (Horizontal Error)

Means Comparisons				
Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.00	1.92	5.06	8.96
1200	-1.92	0.00	3.14	7.04
600	-5.06	-3.14	0.00	3.90
0	-8.96	-7.04	-3.90	0.00
Comparisons for all pairs using Tukey-Kramer HSD				
q* = 2.56909	Alpha= 0.05			
Abs(Dif)-LSD	1800	1200	600	0
1800	-0.26	1.70	4.85	8.76
1200	1.70	-0.18	2.98	6.90
600	4.85	2.98	-0.13	3.78
0	8.76	6.90	3.78	-0.11
Positive values show pairs of means that are significantly different.				

[6] LSD is proportional to the square root of the sum of the squared product of q* and the standard error of both means being compared. The q* value is a quantile similar to the t value of a Student t distribution but expanded to account for the alpha being held for the entire set of comparisons (SAS Institute, 1995).

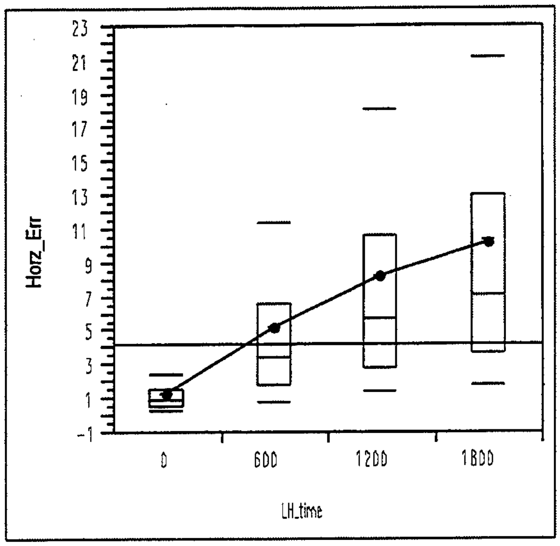

Figure 3.3-3: Quantile / Mean Comparison of Horizontal Error Vs. LH

In summary, the mean horizontal error is statistically significant at the look ahead times of zero, 600, 1200, and 1800 seconds. Referring to Figure 3.3-3, the sample means are also increasing as the look ahead time (LH) increases, ranging from a sample mean of 1.2 nautical miles at look ahead zero to 10.2 at 1800 seconds (i.e. 30 minutes). The mean of all observations is drawn as a horizontal line across the entire plot. The median is also increasing from 0.96 nautical miles at zero look ahead time to 7.1 at 1800 seconds. The horizontal lines in Figure 3.3-3's boxes correspond to the 10, 25, 50, 75, and 90 percentiles of the distribution of the sampled horizontal errors, respectively[7]. Tested statistically with the Levene Test earlier, the box ranges illustrate that the spread of the horizontal error is also increasing as the look ahead time increases.

The analysis continues by examining the lateral, longitudinal, and vertical errors using the same methods described for the horizontal error. The results are summarized in Table 3.3-6 and the means comparisons of the lateral, longitudinal and vertical errors are shown in Figures 3.3-4 through 3.3-6. The descriptive statistics of the absolute values of the four errors are tabulated in Appendix A.1.

[7] The percentiles illustrated in the Figure 3.3-3 as horizontal lines and box ends are described in detail in Appendix A.0.

Table 3.3-6: Statistical Results LH 0-30 minutes for All Altitudes

Error Type	Levene Test	Welch Test	Tukey-Kramer[8]	Observations
Horizontal	Yes	Yes	Yes – all	Mean and variance increases as look ahead time (LH) increases. Means range from 1.2 to 10.2 nautical miles (nm).
Lateral	Yes	Yes	Yes-3of6	Mean at LH 0 different from others. Mean and variance increase as LH increases. Means range from -0.02 to -0.22 nm.
Longitudinal	Yes	Yes	Yes – 5of6	Both mean and variance different. Only means at LH 1200 versus 1800 not different. Means increase in value as LH increases, ranging from –0.02 to 0.88 nm.
Vertical	Yes	Yes	Yes –all	Mean ranges from 49 to –327 feet. Mean (becomes more negative) and variance increase as LH increases.

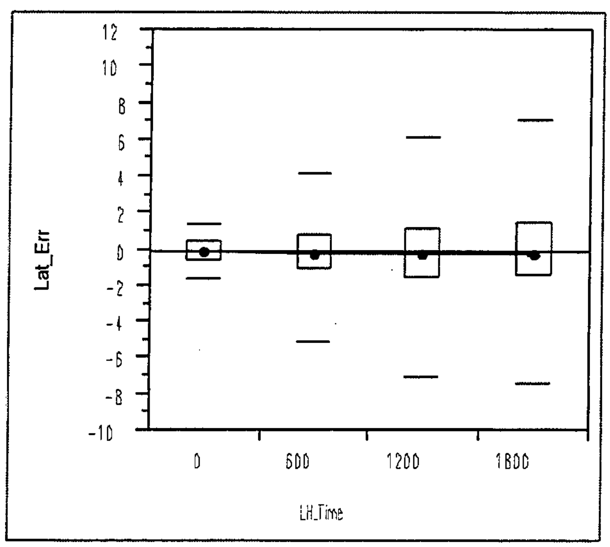

Figure 3.3-4: Quantile / Mean Comparison of Lateral Error Vs. LH

[8] In this table, "yes" means test provides evidence to reject hypothesis that means or variances are equal. "Yes-all" means Tukey-Kramer found all pairs of means not equal, and "Yes-1of6" means it found only 1 pair of means not equal in 6 combinations of pairwise comparisons.

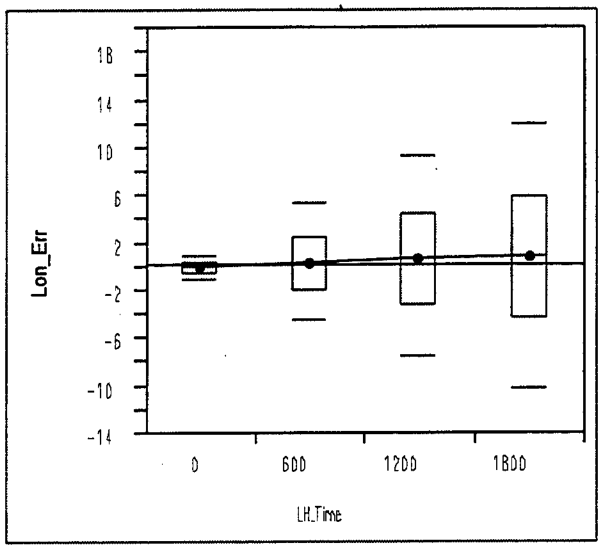

Figure 3.3-5: Quantile / Mean Comparison of Longitudinal Error Vs. LH

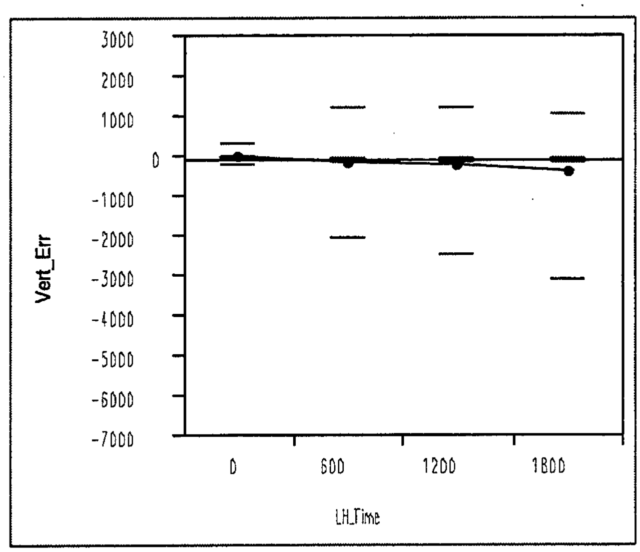

Figure 3.3-6: Quantile / Mean Comparison of Vertical Error Vs. LH

3.3.1.2 Samples at altitudes above 18,000 feet

For samples at altitudes above 18,000 feet only, the results are summarized in Table 3.3-7. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-7: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	Yes	Yes	Yes – all	Mean and variance increases as LH increases. Means range from 1.1 to 10.6 nm and standard deviation ranges from 0.94 to 11.5 nm.
Lateral	Yes	Yes	Yes-3of6	Only LH 0 different from others. Variance increases as LH increases. Means range from –0.02 to -0.44 nm.
Longitudinal	Yes	Yes	Yes – 5of6	Mean LH 1200 versus 1800 not different. Mean and variance increase with LH.
Vertical	Yes	Yes	Yes – 5of6	Mean ranges from 39 to -180 feet. Variance increases with LH. T-K Test shows no difference between means at 0 and 600 seconds LH.

3.3.1.3 Discussion of the effect of look ahead time

In general, look ahead time does have a significant effect on each sample mean and increases as the look ahead time increases. For horizontal error, the sample means increase over 10 nautical miles from zero to 1800 seconds (i.e. 30 minutes) look ahead time. Since lateral and longitudinal errors are exact orthogonal components of the horizontal error, it is interesting to note that the dominant source of the increase in horizontal error with look ahead time is the longitudinal error. Longitudinal error increases around one nautical mile with look ahead time zero to 30 minutes, while the absolute longitudinal error does increase around seven nautical miles. The lateral error increases by around a 0.25 nautical mile with look ahead time, and its absolute error increases by around four nautical miles. Statistically the lateral error only shows a difference between look ahead zero and the others, while longitudinal shows a difference in practically all look ahead times except between 1200 and 1800 seconds. Therefore, most of the error affecting an increase in the horizontal dimension as look ahead time increases is dominated by the longitudinal component.

Another aspect of the longitudinal error is the direction of the increase as look ahead time increases. On average, longitudinal error becomes more positive as look ahead increases. The aircraft on average are getting ahead of the prediction or conversely the predictions are getting behind the aircraft. The specific reasons for this will have to be left for future study but could be related to anything from URET's aircraft modeling parameters to weather profiles of the particular day analyzed.

The vertical error also shows a significant difference between sample means, but the mean differences like the lateral error are relatively small, ranging around 300 to 400 feet for all altitudes and around 200 feet for samples above 18,000 feet. For the vertical error, the sample means may be relatively small, but the variance increases dramatically with a standard deviation

ranging from around 600 to 2300 feet. In other words, the central tendency of the vertical error may not change dramatically, but the spread increases significantly as look ahead time increases.

In general, the variance increases significantly for all the error variables in both horizontal and vertical dimensions. For horizontal error, the standard deviation increases over nine nautical miles from zero to 1800 look ahead time. This range of nine nautical miles holds true for lateral and longitudinal errors as well. The spread of the errors increases as the look ahead time increases.

The differences between the trajectory prediction errors from samples at all altitudes versus above 18,000 feet are small, and they lead to the same conclusions about the distributions.

3.3.2 Analysis of Flight Type on Trajectory Accuracy

Flight type is determined by examining the origin and destination airports in a flight plan. The flight type includes four possible levels referred to as overflight, departure, arrival, and internal. Overflight is an aircraft whose origin and destination airports are outside the particular center's airspace, ZID in this case. Departures leave an airport inside the center, and arrivals land at an airport inside the center. The internals include flights that have both origin and destination airports inside the center.

The analysis that follows examines whether the means of the trajectory prediction errors of the different flight types are significantly different at the four look ahead times of 0, 600, 1200, and 1800 seconds. This analysis focuses on these four look ahead times and flight types against the signed lateral, longitudinal, vertical, and horizontal errors. Appendix A.1 contains a more complete set of look ahead times and also includes the descriptive statistics on the unsigned or absolute values of the errors. Figures 3.3-7 through 3.3-10 plot the means as a function of look ahead time (LH) where OVR denotes overflights, ARR denotes arrivals, DEP denotes departures, and INR denotes internals.

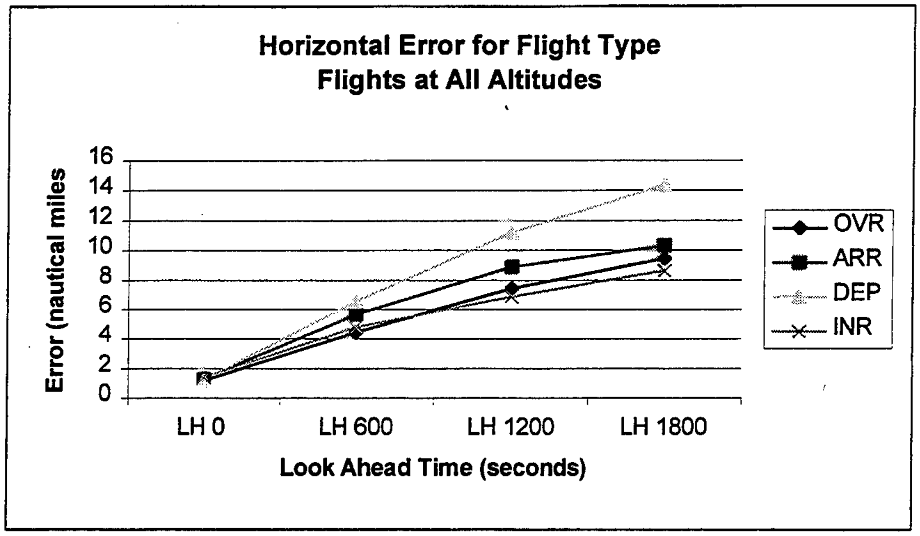

Figure 3.3-7: Sample Means for Horizontal Error per Flight Type and LH

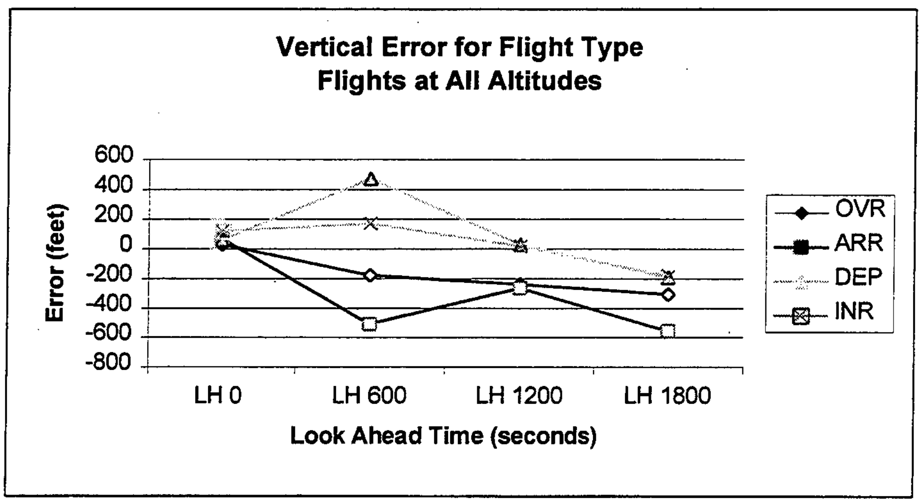

Figure 3.3-8: Sample Means for Vertical Error per Flight Type and LH

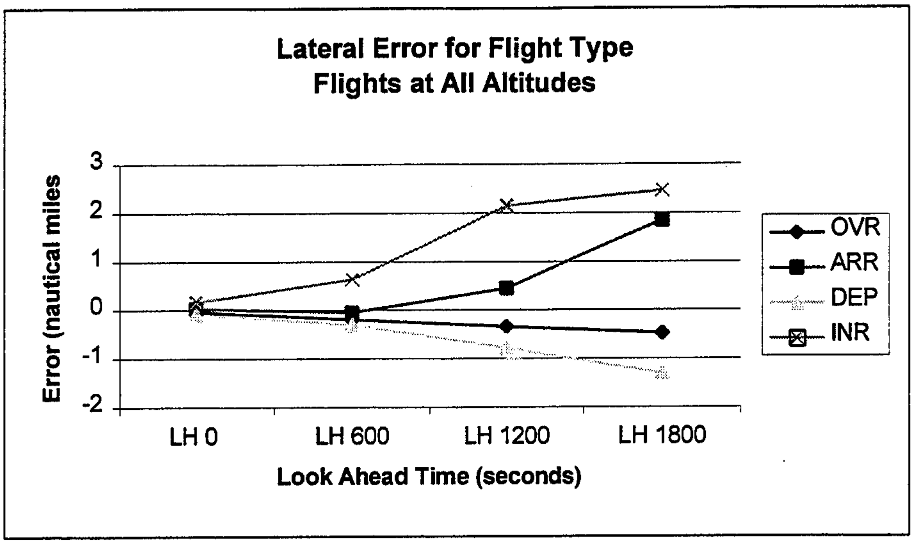

Figure 3.3-9: Sample Means for Lateral Error per Flight Type and LH

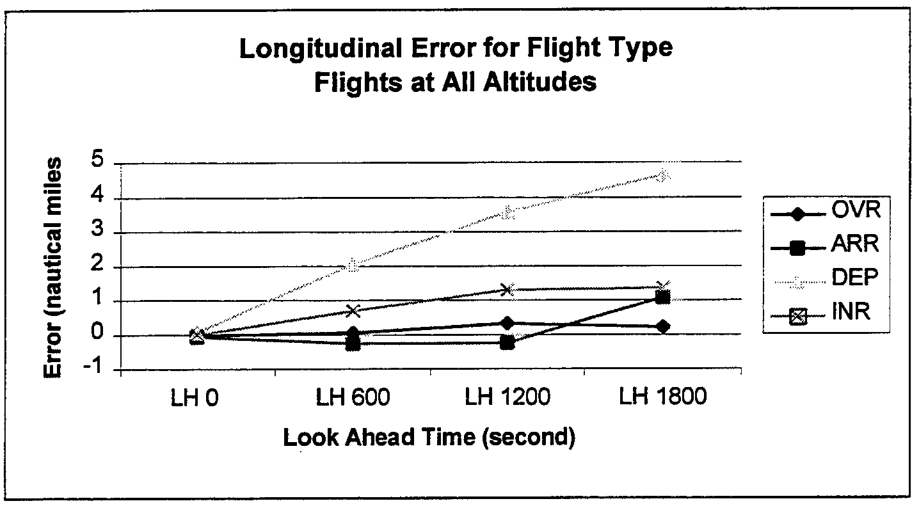

Figure 3.3-10: Sample Means for Longitudinal Error per Flight Type and LH

3.3.2.1 Samples at all altitudes

Statistical results for all altitudes are summarized in Table 3.3-8. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-8: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-5of6	T-K Test shows arrivals and internals are not significantly different.
Lateral	0	Yes	Yes	Yes-5of6	Only overflights versus departures are not different.
Long.	0	Yes	Yes	Yes-3of6	Only internals are not significantly different from the others.
Vertical	0	Yes	Yes	Yes-3of6	Only overflights are different than the other three flight types. Overflights have less vertical error with a sample mean of 32 feet compared to a range of 61-121 feet.
Horizontal	600	Yes	Yes	Yes-5of6	T-K shows overflights and internals are not significantly different.
Lateral	600	Yes	Yes	Yes-2of6	Only internals versus either overflights or departures are significantly different.
Long.	600	Yes	Yes	Yes-5of6	Only internals versus overflights are not different.
Vertical	600	Yes	Yes	Yes-all	Although all the means are different, arrivals and departures are around 500 feet in error on average and overflights and internals are around 200 feet.
Horizontal	1200	Yes	Yes	Yes-5of6	T-K shows overflights and internals are not significantly different.
Lateral	1200	Yes	Yes	Yes-5of6	Only overflights versus departures are not significantly different.
Long.	1200	Yes	Yes	Yes-4of6	Only internals versus either overflights or arrivals are not significantly different.
Vertical	1200	Yes	Yes	Yes-2of6	Departures versus overflights or arrivals are significantly different.
Horizontal	1800	Yes	Yes	Yes-3of6	T-K shows only departures are significantly different to the other types.
Lateral	1800	Yes	Yes	Yes-3of6	Departures versus either arrivals or internals and arrivals versus overflights are significantly different.
Long.	1800	Yes	Yes	Yes-2of6	Departures versus arrivals and overflights are significantly different.
Vertical	1800	Yes	Yes	Yes-2of6	All means negative ranging from 200 to 600 feet error. T-K shows arrivals versus overflights and departures are different.

3.3.2.2 Samples at altitudes above 18,000 feet

Statistical results for altitudes above 18,000 feet are summarized in Table 3.3-9. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-9: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-4of6	T-K Test shows internals versus overflights and arrivals are not different.
Lateral	0	Yes	Yes	Yes-1of6	Only arrivals versus departures are significantly different.
Long.	0	Yes	Yes	Yes-3of6	Only internals are not different from the other flight types.
Vertical	0	Yes	Yes	Yes-4of6	T-K shows departures versus overflights and arrivals are significantly different. Overflights and departures have less error with around 32 feet on average.
Horizontal	600	Yes	Yes	Yes-3of6	Only internals vs. others are not different.
Lateral	600	Yes	Yes	Yes-1of6	Only overflights versus departures are significantly different.
Long.	600	Yes	Yes	Yes-5of6	Only internals versus departures are not different.
Vertical	600	Yes	Yes	Yes-all	All means are different ranging from around -168 to 3700 feet.
Horizontal	1200	Yes	Yes	Yes-3of6	Only internals vs. others are not different, based on one sample so inconclusive.
Lateral	1200	Yes	Yes	Yes-3of6	All are different except internals which are based on one sample.
Long.	1200	Yes	Yes	Yes-2of6	Departures versus overflights and arrivals are different. Only one sample for internals.
Vertical	1200	Yes	Yes	Yes-all	All means are significantly different, but internals inconclusive with one sample.
Horizontal	1800	Yes	Yes	Yes-2of3	No internal samples. Departures differ from overflights and arrivals.
Lateral	1800	Yes	Yes	Yes-All	No internal samples. All means and variance different.
Long.	1800	Yes	Yes	Yes-2of3	No internal samples. Only overflights and arrivals are not different.
Vertical	1800	Yes	Yes	Yes-2of3	No internal samples. Arrivals differ from overflights and departures.

3.3.2.3 Discussion of the effect of flight type

In general, flight type did have a significant effect on the performance of the trajectory predictions but not nearly as much as the look ahead time. In general, overflights performed the best at the lower look ahead times for all samples, but internals and overflights did not have significant differences at the larger look ahead times for all altitude samples. Any conclusions on internals for the samples above 18,000 feet are inconclusive since the sample sizes were small or

nonexistent. For horizontal error, departures seem to have the largest error, ranging from 1.2 to 14.4 nautical miles, as look ahead time increases. For vertical error, the same is true for arrivals. That is, for arrivals the vertical error increases as look ahead time increases the most from around 60 to –550 feet on average.

There were relatively small sample sizes for internals at the larger look ahead times. The samples are taken along a trajectory for a look ahead time window up to 30 minutes (i.e. 1800 seconds), but the internals have much shorter flights on average. The internals have an average track life of around 22 minutes, compared to the other flight types which have an average track life of around 35 minutes.

3.3.3 Analysis of Horizontal Phase of Flight on Trajectory Accuracy

Horizontal phase of flight is calculated for each HCS track report and extracted for the trajectory accuracy measurements. This factor is categorized into two levels: straight or turn. The PHASE_D program that detects turns, described in Section 2.4.6.1, had its parameters set to protect against noise in the track data. As a result, rapid turns are detected but shallow turns may be missed. A turn is determined by a nine degree angle (or greater) generated by the two segments drawn from the previous position to the current position and the current position to the next position report.

The analysis that follows examines whether the mean of the trajectory prediction error at the two horizontal phases of flight are significantly different statistically at the four look ahead times of zero, 600, 1200, and 1800 seconds. This analysis will focus on these four look ahead times and two phases of flight against the signed lateral, longitudinal, vertical, and horizontal errors. Appendix A.1 contains a more complete set of look ahead times and also includes the descriptive statistics on the unsigned or absolute values of the errors. Figures 3.3-11 to 3.3-14 plot the means for each horizontal phase of flight as a function of look ahead time (LH), where STR denotes straight and TRN denotes turning.

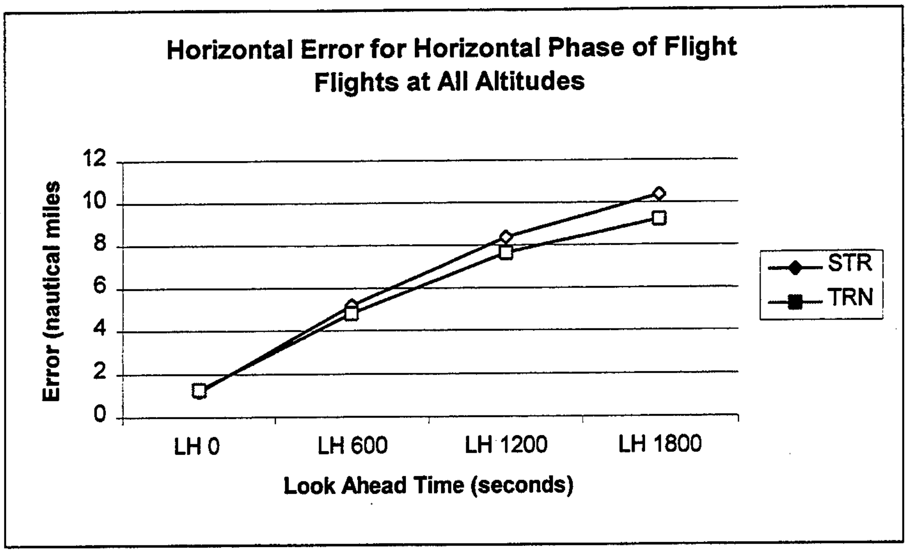

Figure 3.3-11: Sample Means for Horizontal Error per Horizontal Phase of Flight and LH

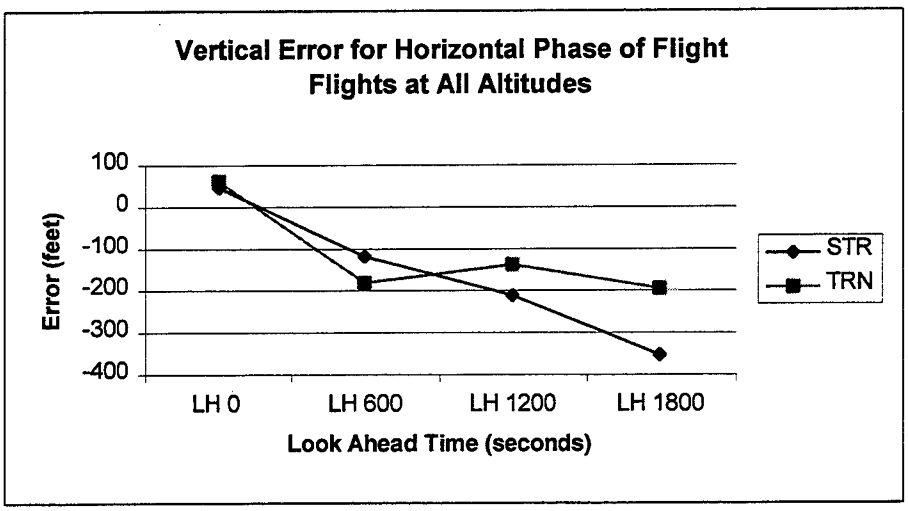

Figure 3.3-12: Sample Means for Vertical Error per Horizontal Phase of Flight and LH

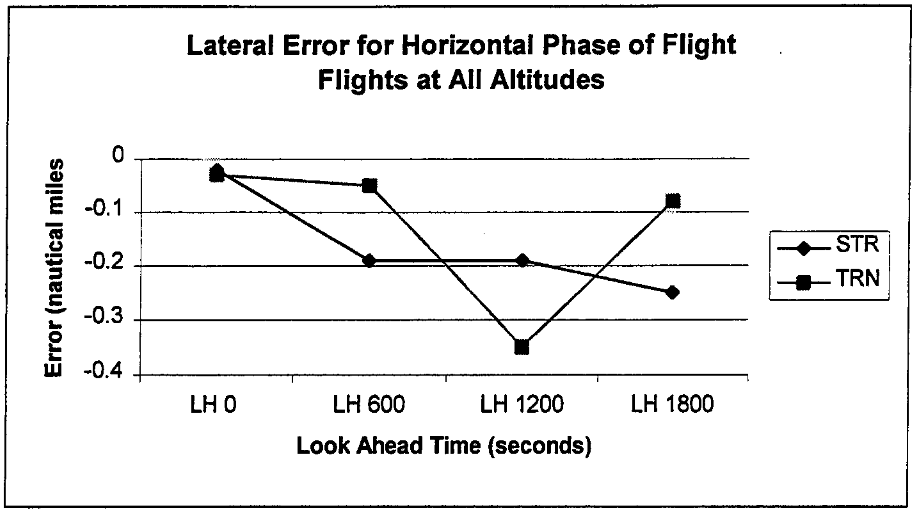

Figure 3.3-13: Sample Means for Lateral Error per Horizontal Phase of Flight and LH

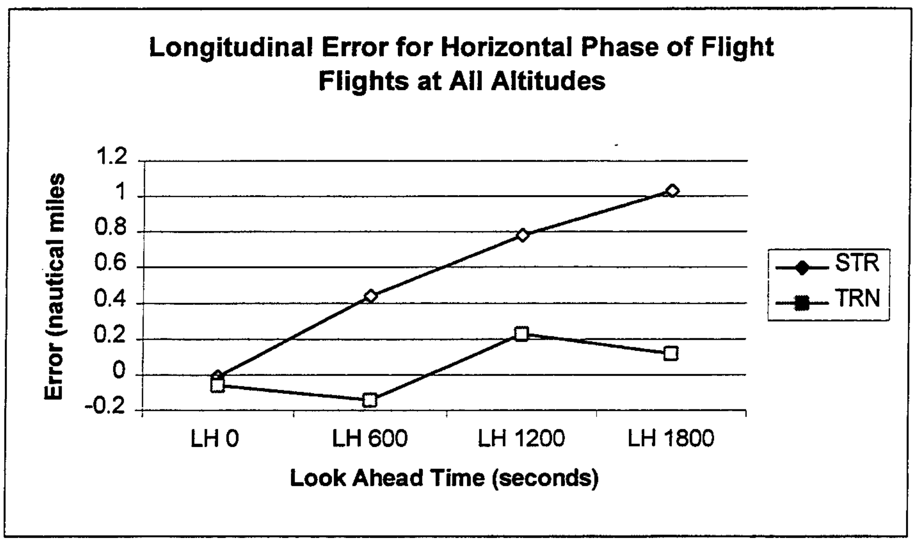

Figure 3.3-14: Sample Means for Longitudinal Error per Horizontal Phase of Flight and LH

3.3.3.1 Samples at all altitudes

The results for all altitudes are summarized in Table 3.3-10. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-10: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes	Both mean and variance are significantly different. The means are around 600 feet different.
Lateral	0	Yes	No	No	Only variance is significantly different.
Long.	0	Yes	Yes	Yes	Both mean (around 300 feet) and variance are significantly different.
Vertical	0	Yes	No	No	Only variance is significantly different.
Horizontal	600	Yes	Yes	Yes	Both mean (around 900 feet) and variance are significantly different.
Lateral	600	Yes	No	No	Only variance is significantly different.
Long.	600	No	Yes	Yes	Means are different, around 0.6 nm.
Vertical	600	Yes	No	No	Only variance is significantly different.
Horizontal	1200	Yes	Yes	Yes	Both mean and variance are significantly different. The means differ around 1 nautical mile.
Lateral	1200	Yes	No	No	Only variance is significantly different.
Long.	1200	No	Yes	Yes	Means are significantly different. The means differ around 0.5 nautical mile.
Vertical	1200	No	No	No	Do not differ statistically.
Horizontal	1800	Yes	Yes	Yes	Both mean and variance are significantly different. The means differ around 1.2 nautical miles.
Lateral	1800	Yes	No	No	Only variance is significantly different.
Long.	1800	No	Yes	Yes	Means are significantly different. The means differ 0.9 nm.
Vertical	1800	No	Yes	Yes	Means are significantly different. The means differ around 160 feet.

3.3.3.2 Samples at altitudes above 18,000 feet

The results are summarized in Table 3.3-11. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-11: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	No	No	Only variance is significantly different.
Lateral	0	No	No	No	Do not differ statistically.
Long.	0	No	No	No	Do not differ statistically.
Vertical	0	No	No	No	Do not differ statistically.
Horizontal	600	No	No	No	Do not differ statistically.
Lateral	600	No	No	No	Do not differ statistically.
Long.	600	No	Yes	Yes	Means differ around a 0.6 nm.
Vertical	600	No	No	No	Do not differ statistically.
Horizontal	1200	Yes	Yes	Yes	Both mean and variance are significantly different. The means differ around 1 nautical mile.
Lateral	1200	Yes	No	No	Only variance is significantly different.
Long.	1200	No	No	No	Do not differ statistically.
Vertical	1200	No	No	No	Do not differ statistically.
Horizontal	1800	Yes	Yes	Yes	Both mean and variance are significantly different. The means differ around 1.3 nautical miles.
Lateral	1800	Yes	No	No	Only variance is significantly different.
Long.	1800	No	Yes	Yes	Means are significantly different. The means differ around 1.3 nm.
Vertical	1800	No	Yes	Yes	Means are significantly different. The means differ around 230 feet.

3.3.3.3 Discussion of the effect of Horizontal Phase of Flight

In general, the horizontal phase of flight, i.e. whether an aircraft is turning or on a straight path, had a significant effect on the horizontal prediction error and longitudinal error only for the all altitude samples. The magnitude of these differences between the means was rather small, approximately 0.1 to 1.2 nautical miles from zero to 1800 seconds look ahead time, respectively. The only other pattern of significant differences between means was the vertical error at 1800 seconds look ahead time, however the differences were very small, at around 150 feet. The results suggest that horizontal phase of flight has only a minor impact on the trajectory performance. There has also been some discussion on the need for analysis a small distance before and after the actual turn. The technique currently used for determining an aircraft is turning is not sufficiently robust in filtering out the noise of the HCS track reports nor can it examine the straight path around the turn. As a result, the statistical analysis of the effect of turns should be interpreted advisedly and the algorithm will be revisited in the future.

3.3.4 Analysis of Vertical Phase of Flight on Trajectory Accuracy

Similar to horizontal phase of flight, vertical phase of flight is calculated for each interpolated HCS track report and extracted for the trajectory accuracy measurements. Vertical phase of flight is categorized into three categories: level, ascending, or descending. The track points are only labeled as climbing or descending for reasonably large climbs and descents to protect against noise in the position data, but this also prevents detection of low rate climbs and descents (i.e. smaller than 900 feet per minute). A climb or descent is determined by calculating the difference in altitude between the current interpolated track position and the next track position. If the absolute difference is less than 150 feet, the current position of the aircraft is considered in level flight, otherwise the aircraft is in a climb or descent depending on the direction up or down. Since the track positions are interpolated at 10 second intervals, the required gradient for the climbing or descending aircraft is greater than or equal to 15 feet per second or 900 feet per minute. The phase of flight algorithm is described in detail in Section 2.4.6.

The analysis that follows examines whether the mean of the trajectory prediction error at the three vertical phases of flight are significantly different statistically at the four look ahead times of zero, 600, 1200, and 1800 seconds. This analysis focuses on these four look ahead times and three phases of flight against the signed lateral, longitudinal, vertical, and horizontal errors. Appendix A.1 contains a more complete set of look ahead times and also includes the descriptive statistics on the unsigned or absolute values of the errors. Figures 3.3-15 to 3.3-18 plot the means for each vertical phase of flight as a function of look ahead time (LH), where LEV denotes level flight, ASC denotes ascending and DES denotes descending.

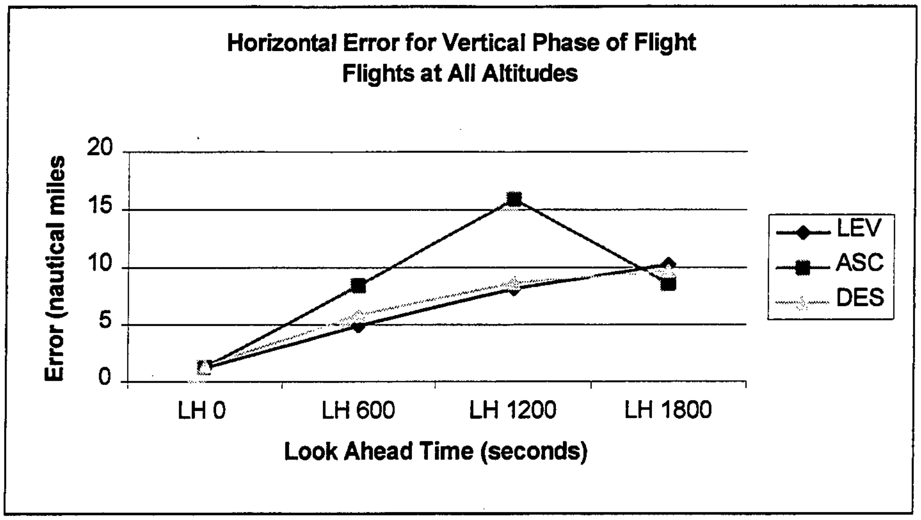

Figure 3.3-15: Sample Means for Horizontal Error per Vertical Phase of Flight and LH

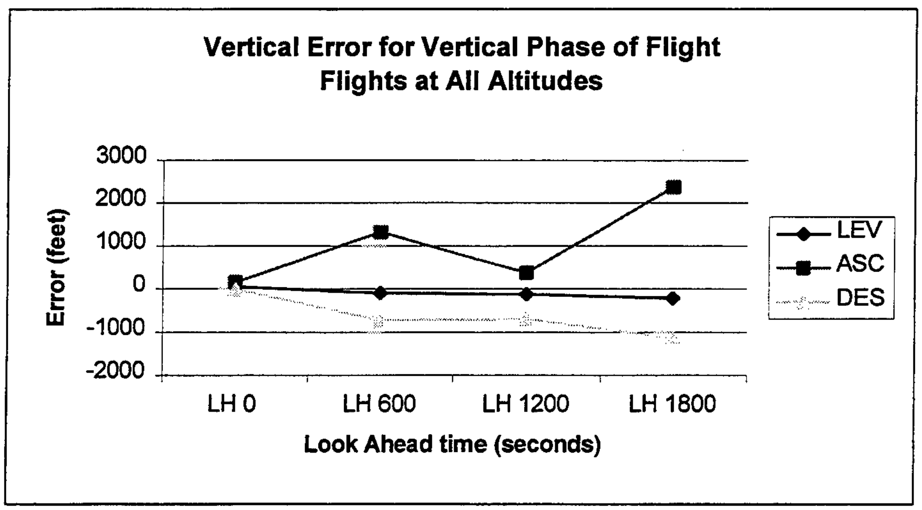

Figure 3.3-16: Sample Means for Vertical Error per Vertical Phase of Flight and LH

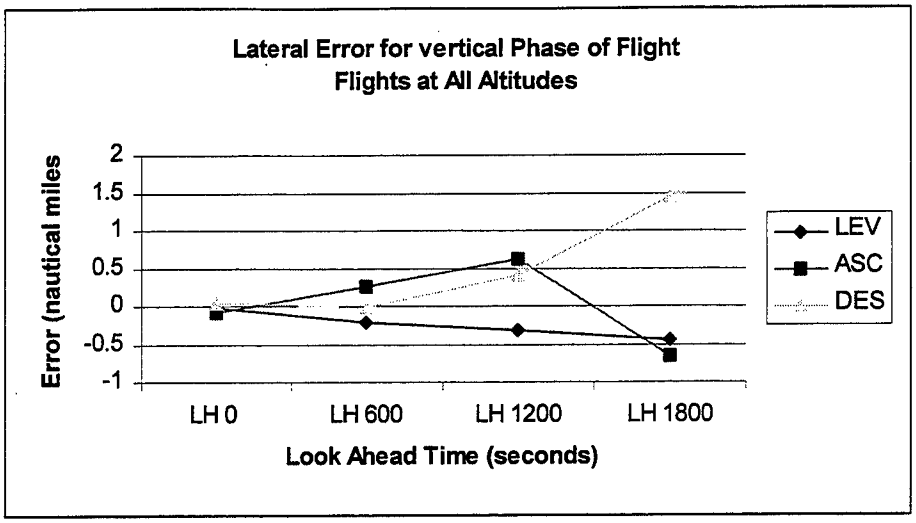

Figure 3.3-17: Sample Means for Lateral Error per Vertical Phase of Flight and LH

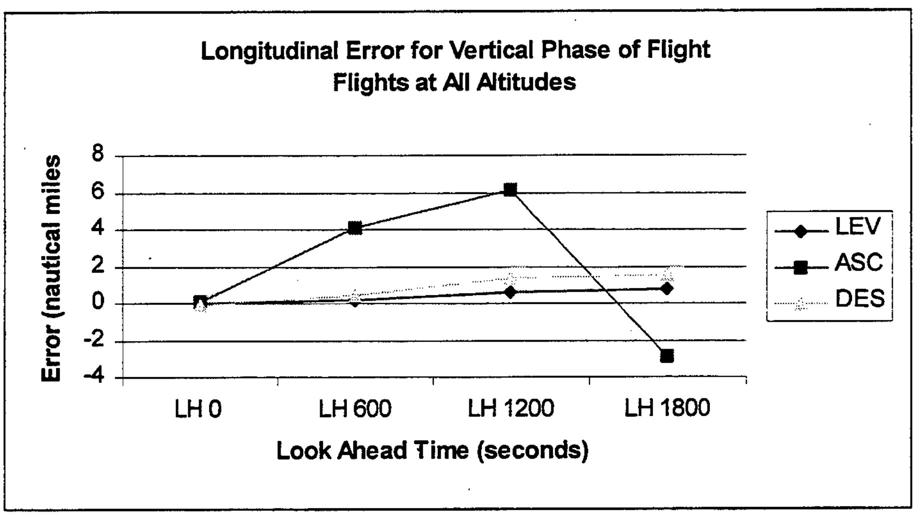

Figure 3.3-18: Sample Means for Longitudinal Error per Vertical Phase of Flight and LH

3.3.4.1 Samples at all altitudes

The results are summarized in Table 3.3-12. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-12: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-2of3	Only level versus ascent not different, but others around a maximum of 1000 feet different.
Lateral	0	Yes	Yes	Yes-all	Both mean and variance are significantly different.
Long.	0	Yes	Yes	Yes-all	Both mean and variance are significantly different.
Vertical	0	Yes	Yes	Yes-all	Both mean (around 160 feet) and variance are significantly different.
Horizontal	600	Yes	Yes	Yes-all	Both mean (by as much as 3.6 nm) and variance are significantly different.
Lateral	600	Yes	Yes	Yes-1of3	Only ascent versus level differ.
Long.	600	Yes	Yes	Yes-all	Both mean (by as much as 3.9 nm) and variance are significantly different.
Vertical	600	Yes	Yes	Yes-all	Both mean (by as much as 2000 feet) and variance are significantly different.
Horizontal	1200	Yes	Yes	Yes-2of3	Only level versus descent not different, and others differ by as much as 7.75 nm.
Lateral	1200	No	Yes	Yes-1of3	Only means descent versus level are significantly different.
Long.	1200	Yes	Yes	Yes-all	Mean (by as much as 5.5 nm) and variance are significantly different.
Vertical	1200	Yes	Yes	Yes-2of3	Both mean and variance are significantly different, except level versus ascent. The means differ by as much as 1100 feet.
Horizontal	1800	Yes	No	No	Only variance is significantly different. Inconclusive on ascents, only 11 samples.
Lateral	1800	No	Yes	Yes1of3	Only mean of descent versus level different. Inconclusive on ascents, only 11 samples.
Long.	1800	No	No	No	Do not differ statistically. Inconclusive on ascents, only 11 samples.
Vertical	1800	Yes	Yes	Yes	Means are significantly different. The means differ by as much as 3500 feet. Inconclusive on ascents, only 11 samples.

3.3.4.2 Samples at altitudes above 18,000 feet

The results are summarized in Table 3.3-13. The detailed histograms and statistical tables are located in Appendix A.1.

Table 3.3-13: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-2of3	Only level versus ascent not different, but others around a maximum of 600 feet different.
Lateral	0	Yes	Yes	No	Tukey-Kramer shows no difference in means but has less power than Welch Test which had a p-value of 0.48.
Long.	0	Yes	Yes	Yes-2of3	Only descent versus level means are not significantly different
Vertical	0	Yes	Yes	Yes-all	Both mean (around 220 feet) and variance are significantly different.
Horizontal	600	Yes	Yes	Yes-all	Both mean (by as much as 3.5 nm) and variance are significantly different.
Lateral	600	Yes	No	No	Only variance is significantly different.
Long.	600	Yes	Yes	Yes-2of6	Only descent versus level means are not significantly different.
Vertical	600	Yes	Yes	Yes-all	Both mean (by as much as 1600 feet) and variance are significantly different.
Horizontal	1200	Yes	Yes	Yes-2of3	Only level versus descent not different, and others differ by as much as 7 nm.
Lateral	1200	No	Yes	Yes-1of3	Only descent versus level are significantly different.
Long.	1200	Yes	Yes	Yes-2of3	Only descent versus level not different, and others differ by as much as 8.26 nm.
Vertical	1200	Yes	Yes	Yes-2of3	Except level versus ascent means, both mean and variance are different. The means differ by as much as 970 feet.
Horizontal	1800	Yes	Yes	Yes-1of3	Only descent versus level are different, around 2 nautical miles. Inconclusive on ascents, only 10 samples.
Lateral	1800	Yes	Yes	Yes-1of3	Only descent versus level means are different, around 1.75 nautical miles. Inconclusive on ascents, only 10 samples.
Long.	1800	Yes	No	No	Only variance is significantly different. Inconclusive on ascents, only 10 samples.
Vertical	1800	Yes	Yes	Yes-all	Means differ by as much as 3300 feet. Inconclusive on ascents, only 10 samples.

3.3.4.3 Discussion of the effect of Vertical Phase of Flight

In general for both horizontal and vertical dimensions, level flight has the smallest mean and variance error, while ascending flight has the largest as look ahead time increases. At a look ahead time of zero, both ascent and level are not significantly different, but at look ahead time of 1800 not much can be drawn on ascending flight from these samples because around 10 samples were available. In practically all cases, the variance was significantly different. Also as the look ahead time increases, the standard deviation increases and the difference in standard deviation between levels increases. For example, for vertical error at look ahead time zero seconds, the standard deviation ranges from around 620 feet to 940 feet, but at look ahead time 1200 seconds the standard deviation ranges from around 1860 feet to 3200 feet.

4. CTAS Study Results and Observations

The results and observations presented in this section are based on the analysis of seven hours of data recorded at the Fort Worth ARTCC (ZFW). Specific information describing the scenario is presented in Section 4.1. Section 4.2 provides detailed information about one aircraft flight in the study in order to demonstrate the study's methodology, and Section 4.3 presents the results of the application of the trajectory accuracy metrics to CTAS.

4.1 Scenario Description

Figure 4.1-1 provides a data flow diagram logically describing the data files and processes used to obtain the flight plan, track, and trajectory data used for the CTAS analysis. For this study, data was collected from the CTAS installation at ZFW. A recording was made of the HCS flight plans, flight plan amendments, and track messages sent to CTAS over a seven hour period on January 5, 1999. The weather data for the same time period was also recorded.

NASA Ames Research Center provided the ZFW data to ACT-250 in file called *ZFW_010599.cm_sim*. This file was used as input to a playback run through a developmental version of CTAS also provided by NASA Ames. This version of CTAS, called *daisy_view*, was modified by ACT-250 to provide trajectories in its output file. These trajectories consist of 31 points, each point separated in time by 65 seconds. As a result, all of the CTAS trajectories were 1950 seconds or less in length. This output file is identified as *baseline.cm_sim* in Figure 4.1-1. The CTAS Parser Program (CPP) used the *baseline.cm_sim* file to create three files: the *fp.dat* file, containing flight plan data; the *track.dat* file, containing track data; and the *traj_file.dat* file, containing trajectory data. The *fp.dat* file was then concatenated with the *track.dat* file to create an ASCII file called *sn010599.dat,* containing CTAS field data, that has the same format as the *sn022798.dat* described for URET field data in Section 3.1. The *sn010599.dat* file was then used as input to the Flight Plan and Track Data Processing described in Section 2.4.1. The *traj_file.dat* file has the same format as its URET counter part described in Section 3.1 and was used as input to the Trajectory Data Processing described in Section 2.5. The formats of the *sn010599.dat* and *traj_file.dat* files are described in WJHTC/ACT-250, 1998.

Tables 4.1-1 and 4.1-2 summarize the characteristics of the airspace and the aircraft flights through the airspace, respectively, for the subject scenario.

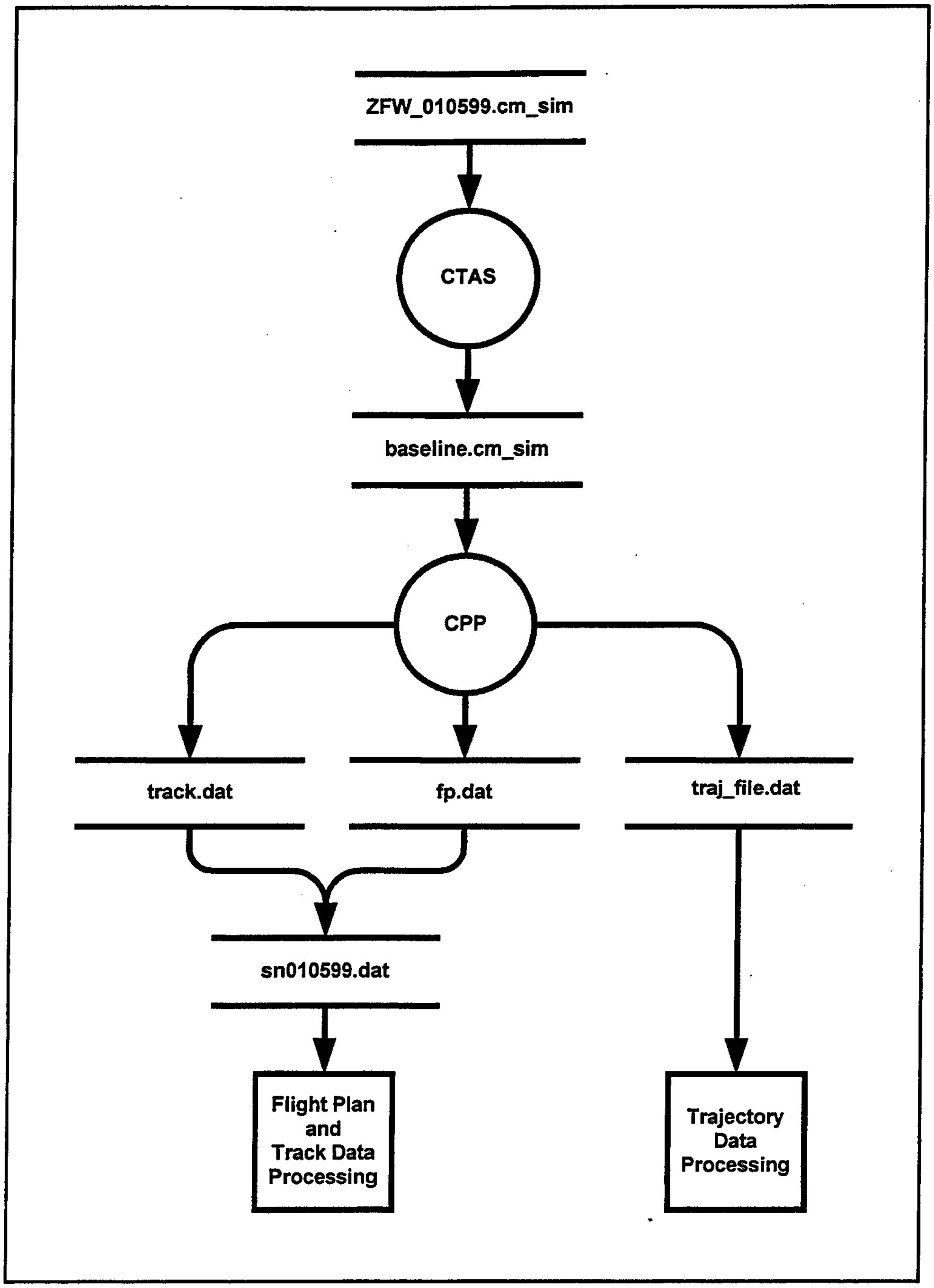

Figure 4.1-1: CTAS Data Sources

4.1.1 Airspace Definition

Table 4.1-1 summarizes the spatial and time boundaries of the ZFW data sample used.

Table 4.1-1: CTAS Scenario - Airspace

Airspace	Fort Worth (ZFW)
Altitude	0 to 60,000 feet
Horizontal boundaries	Defined by the high altitude sectors
Date	January 5, 1999
Start time	18:39:35 UTC (12:40 p.m. local time)
End time	01:43:26 UTC (7:43 p.m. local time)
Duration	07:03:51 or 25,431 seconds

4.1.2 Aircraft Counts

Table 4.1-2 gives the counts of aircraft flights in the sample of air traffic analyzed.

Table 4.1-2: CTAS Scenario – Aircraft Counts

Total number in sample (IFR)	2592
Number excluded	297 (11.5 %)
Number processed	2295 (88.5 % of total)
Number of airliners	1699
Number of General Aviation aircraft	596
Number of jet types in the top 20 aircraft	15
Number of turboprop types in the top 20 aircraft	4
Number of piston types in the top 20 aircraft	1
Average length of track supplied by HCS	37.6 minutes, 2253 seconds, or 189 position reports
Number of overflights	255 (11.1 %)
Number of departures	506 (22.1 %)
Number of arrivals	586 (25.6 %)
Number of internal flights	945 (41.2 %)

4.1.3 Excluded Flights

In measuring the accuracy of track predictions, the true positions of the aircraft are assumed to be the positions reported by the HCS. For some aircraft, it is clear that the HCS reported positions are not correct. Track processing algorithms (in the RDTRACKS program) were used to correct the position data where possible, as described in Section 2.4.3. When it was not possible to correct the data, the individual track reports and in some cases entire flights were deleted from the scenario being examined. Statistics were collected on an aircraft flight only if both a track and a set of predicted trajectories were available. For this analysis of CTAS, there were three categories of excluded aircraft, totaling 297 flights that were deleted from the original set of 2592 IFR flights (a reduction of 11.5 %).

4.1.3.1 Military Flights

Since it is often not possible from flight plan data to accurately predict the flight paths of military flights, which usually are doing either gunnery practice or aerial re-fueling maneuvers, military flights were excluded from the analysis. This was done by selecting out all of the flights which had a call sign containing more than three leading alphabetic characters (e.g., ANVIL, CODER, RACER, SABER, STEEL). Although this is not an exact definition of military aircraft, it was considered to be sufficient for this study. 99 military flights were excluded.

4.1.3.2 Non-initialized Flights

As discussed in Section 2.4, sometimes the HCS processing algorithms are unable to establish a consistent track for the aircraft. Ten of these flights were excluded.

4.1.3.3 Uncertain Position Flights

The processing of the HCS track data requires correcting some of the track reports which are clearly in error. For example, as discussed in Section 2.4.3, sometimes the same XY coordinates are repeated even though the aircraft has moved between the radar reports. In some cases the corrected track reports are substantially different from the original aircraft positions reported by the HCS. This situation implies that we, the experimenters, do not know the true position of the aircraft. Flights having a corrected position report substantially different from the original position report were deleted (188 of these flights were excluded).

4.1.4 Truncated Flights

Often in the HCS track reports several tracks reports are missing or have bad data. If a gap in the track data is short, the missing track reports can be replaced by interpolation. If the gap is large, the position of the aircraft during the gap is unknown. When a large gap in the track data occurs, the track after the gap is discarded. Of the 441,557 radar track position reports, 14,333 or 3.2 % of the radar track position reports were discarded by truncating the tracks after missing or bad data.

Measurements of trajectory prediction errors were made on aircraft either already in the ZFW airspace or approaching the ZFW airspace and about to be in the ZFW airspace. Measurements were not made on aircraft after they left the ZFW airspace. That is, no measurements were made on the portions of the tracks outside ZFW when the aircraft were flying away from the ZFW airspace. 12.6 % of the interpolated track reports were not used for this reason.

4.1.5 Aircraft Mix

The majority of the aircraft in the study are commercial airliners. The top 10 aircraft types account for 1310 of the 2295 flights, or 57.1 % of the total; the top 20 aircraft account for 1632 of the 2295 flights, or 71.1 % of the total. A histogram depicting the frequency of occurrence of the top 20 aircraft is provided in Figure 4.1-2. The aircraft are identified by their FAA type designators. Of the top 20 aircraft, 15 are jets, four are turboprops, and one is a piston-powered aircraft. Table 4.1-3 lists the aircraft manufacturers and model names of the top 10 aircraft. All of the top 10 aircraft are jets except for the Saab & Fairchild 340 which is a turboprop.

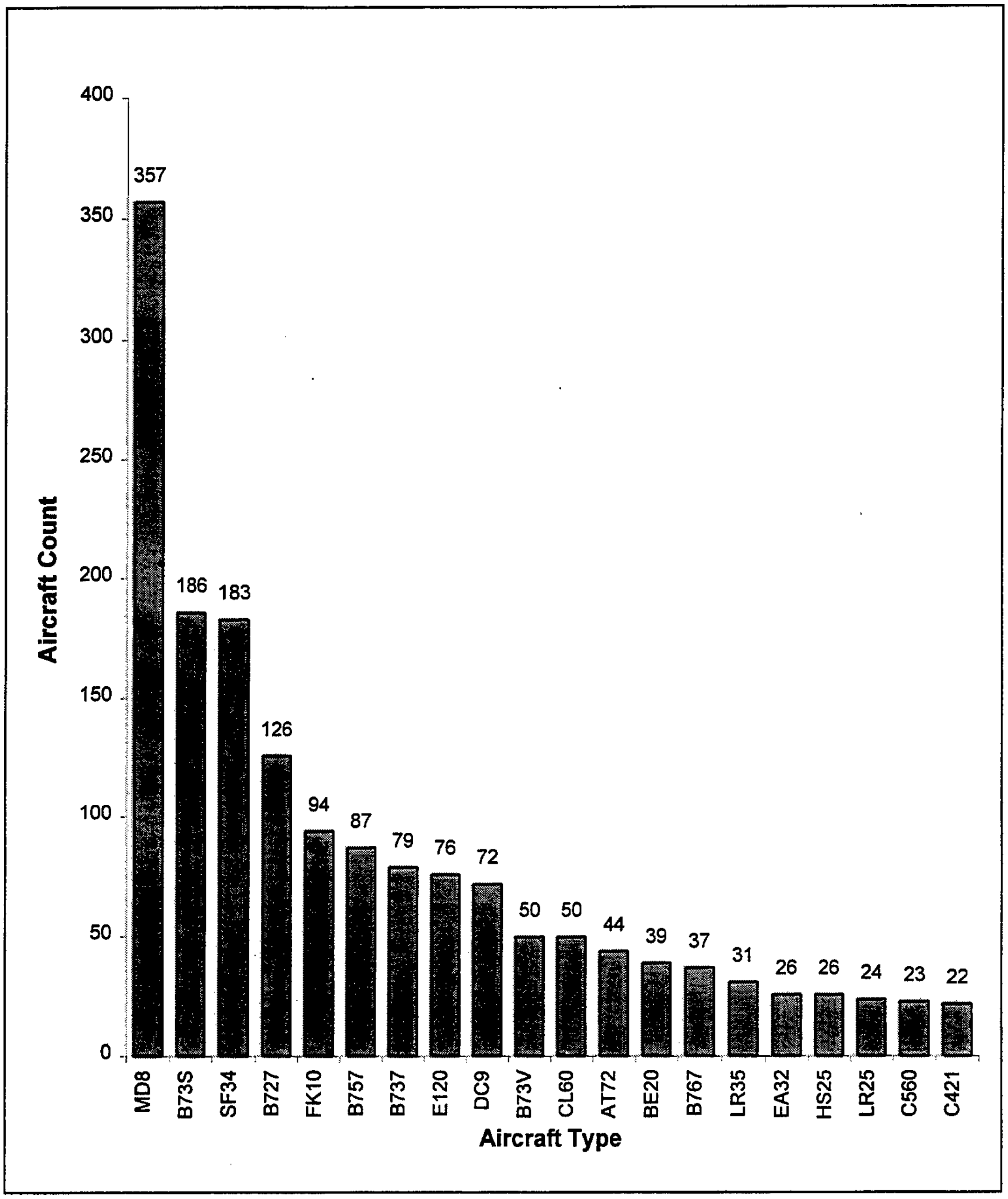

Figure 4.1-2: Top 20 Aircraft Frequency Histogram - ZFW Data

Table 4.1-3: CTAS Scenario Aircraft

RANK	FAA TYPE IDENTIFIER	MANUFACTURER / MODEL	NUMBER OF FLIGHTS	PERCENTAGE OF FLIGHTS
1	MD8	McDonnell-Douglas MD-80	357	15.56 %
2	B73S	Boeing 737 – 300/500	186	8.10 %
3	SF34	Saab & Fairchild 340	183	7.97 %
4	B727	Boeing 727	126	5.49 %
5	FK10	Fokker 100	94	4.10 %
6	B757	Boeing 757	87	3.79 %
7	B737	Boeing 737 – 200	79	3.44 %
8	E120	Embraer EMB 120	76	3.31 %
9	DC9	McDonnell-Douglas DC9	72	3.14 %
10	B73V	Boeing 737	50	2.18 %

4.2 Observations

This section presents observations made during analysis of the data, which provide detailed information about a specific aircraft flight in the CTAS study. These observations are included before the results so that the reader can better understand the methodology, and therefore better understand the statistics and data presented in Section 4.3. While each observation details a typical flight, the errors are not necessarily representative of common occurrences. Appendix C provides additional anomalous flights, which were selected to verify the methodology and to examine trajectory accuracy errors with CTAS.

4.2.1 CTAS1

This flight is a DC9 flying from Dallas/Fort Worth International Airport (DFW) to the Minneapolis-St. Paul International Airport (MSP). It departed via TEX6 through the ZEMMA intersection and proceeded to the Tulsa VORTAC (TUL). From TUL it took J25 to MSP, passing through Kansas City, Des Moines, and Mason City. The cruising altitude was 29,000 feet. The first part of the flight's filed route from DFW to ZEMMA, to TUL and past is shown in Figure 4.2-1.

4.2.1.1 Track Data

The HCS radar track started at 9,500 feet west of DFW and headed initially toward the ZEMMA intersection. About halfway there, the aircraft switched its heading toward the TUL waypoint. The horizontal track is shown in Figure 4.2-1 and in Figure 4.2-3 where the West-East scale (X axis) has been expanded by a factor of 4 to better show the location of the predicted trajectories relative to the track.

During the climb out from DFW to 29,000 feet the aircraft leveled off at 24,000 feet for three minutes before continuing the climb. The aircraft exits the ZFW airspace at level cruise at 29,000 feet. The altitude profile is shown in Figure 4.2-4.

As described in detail in Section 2.4.3, RDTRACKS processed the HCS track which included 195 position reports. First, the time intervals between track reports were examined. There were 35 of the 194 time differences between successive position reports that were equal to 11 seconds. These were changed to 12 seconds. There were 37 reports with a 13 second time difference that were changed to 12 seconds. There was one 10 second time difference that was changed to 12

seconds. There was one 14 second time difference that was changed to 12 seconds. Finally, there were two reports with a 23 second time difference that were changed to 24 seconds.

The first two reports were discarded because of inconsistent altitude values. Another track report defined as stationary had XYZ values of the immediately preceding report. The values of XYZ for this report are replaced with interpolated values. Two reports occur 24 seconds after the immediately preceding report rather than 12 seconds later. An additional interpolated track report is inserted to fill the gap in each case.

4.2.1.2 Trajectory Data

Figure 4.2-2 presents the track time line (labeled "Track") and the time line for 23 of the 168 trajectories recovered for this aircraft. Each of the trajectories is labeled with the trajectory's build time. The sample points for calculating the trajectory accuracy metrics are shown by arrows drawn from the track time line to the latest trajectory available at that sample time. The first sample starts 40 seconds after the time of the initial interpolated track point, which in this example was at 84480 seconds. 19 of the 23 trajectories shown were sampled. The aircraft departed the ZFW Center airspace at 86210 and therefore the data from the last 4 trajectories were not used.

Plots of these trajectories are shown in Figure's 4.2-1, 4.2-3, and 4.2-4. The first 6 sampled trajectories predicted the aircraft would fly to the ZEMMA intersection. After the flight flew by the ZEMMA intersection, the trajectories (Trajectory 7 and later) predicted a flight to TUL. By the eighth sampled trajectory the predicted speed and altitude matched the track.

The first five trajectories predicted the aircraft to climb to 29,000 feet; Trajectories 6 and 7 climbed the aircraft to 23,400 feet and 24,000 feet respectively. Later trajectories climbed the aircraft to 29,000 feet except for Trajectory 10 which climbed the aircraft to 28,500 feet.

4.2.1.3 Metrics

Table 4.2-1 shows the trajectory metrics calculated for this aircraft. The longitudinal and lateral errors are in nautical miles; the vertical errors are in feet. As discussed in Section 2.5.1, a sample is taken 40 seconds after the start of track and then repeated each two minutes until either the track ends, the trajectory ends, or the track leaves the center. At each sample time the distance between the track and trajectory was calculated at the current time and at look ahead times of 300 seconds or five minute increments into the future; resulting in look ahead times of 0, 300, 600, 900, 1200, 1500, and 1800 seconds.

The data shows that the lateral and longitudinal errors, although very small at low look ahead times because CTAS builds a new trajectory with each new track point, increased at the higher look ahead times early in the flight. This is because the aircraft flew inside the ZEMMA waypoint and flew direct to TUL.

It can be seen in Figure 4.2-4 that the initial estimates of climb rate were too high. By Trajectory 5 the estimate matched the actual track climbing rate. The interim altitude of 24,000 feet confuses the prediction of the final cruising altitude. Both the errors in estimating the climb rate and the errors in predicting the cruising altitude produce the large vertical prediction errors listed in Table 4.2-1.

Table 4.2-1 also shows that metrics were not computed after time 86160 because the aircraft departed the ZFW airspace at 86210.

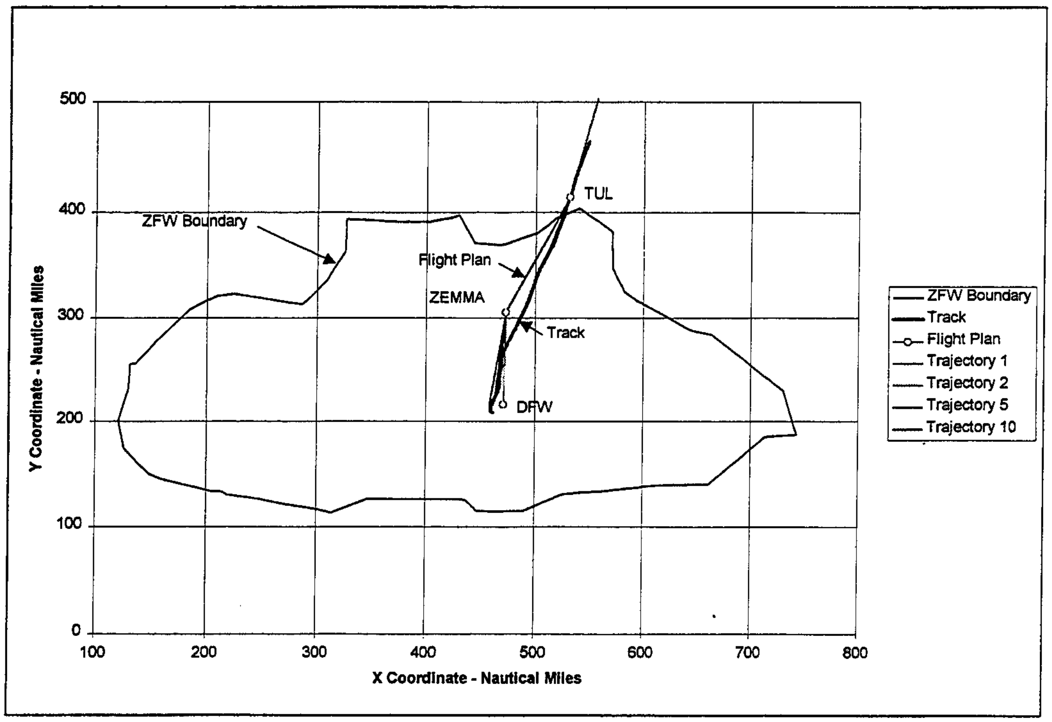

Figure 4.2-1: Aircraft Track and Route

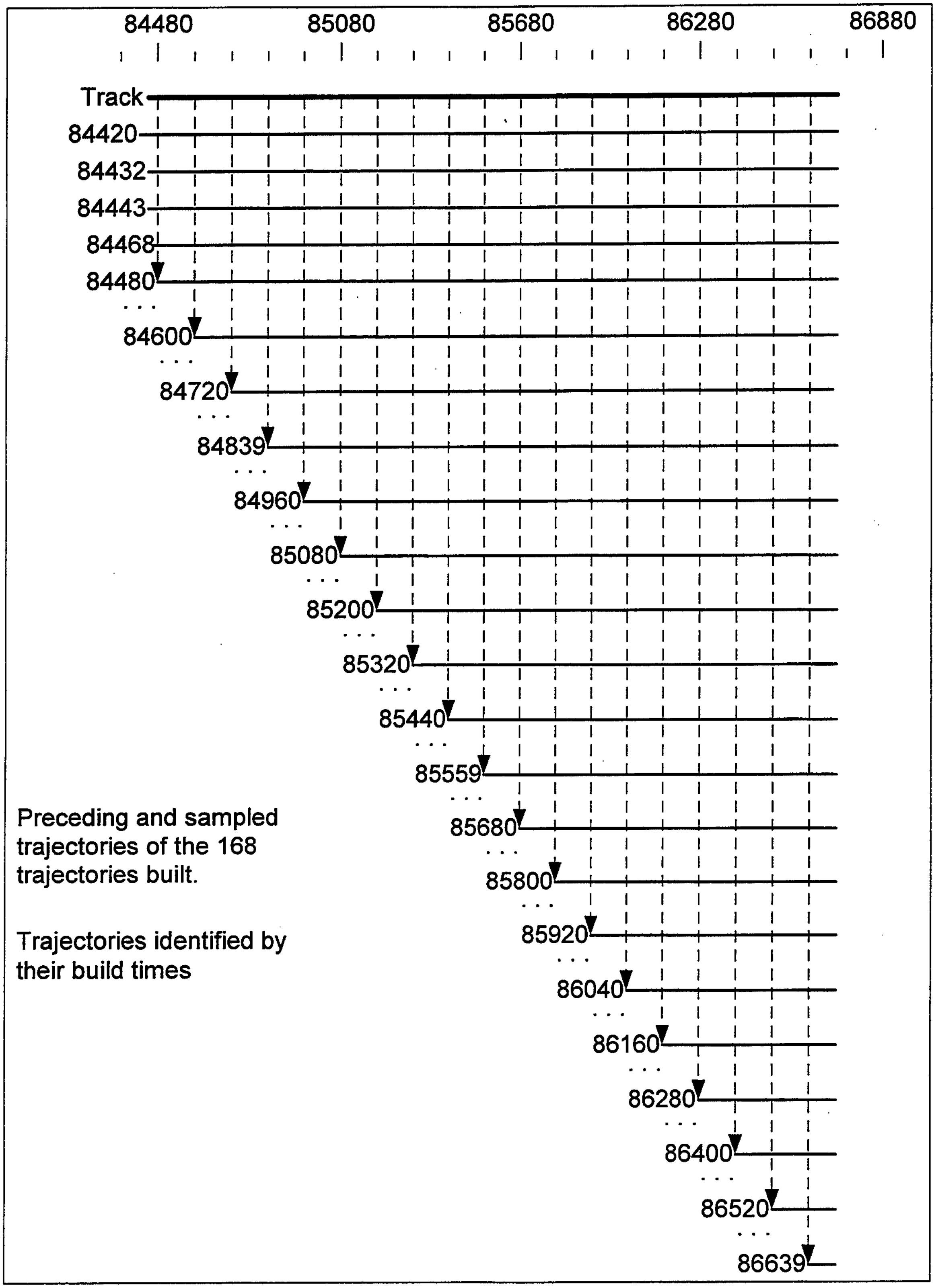

Figure 4.2-2: Sampled Trajectories

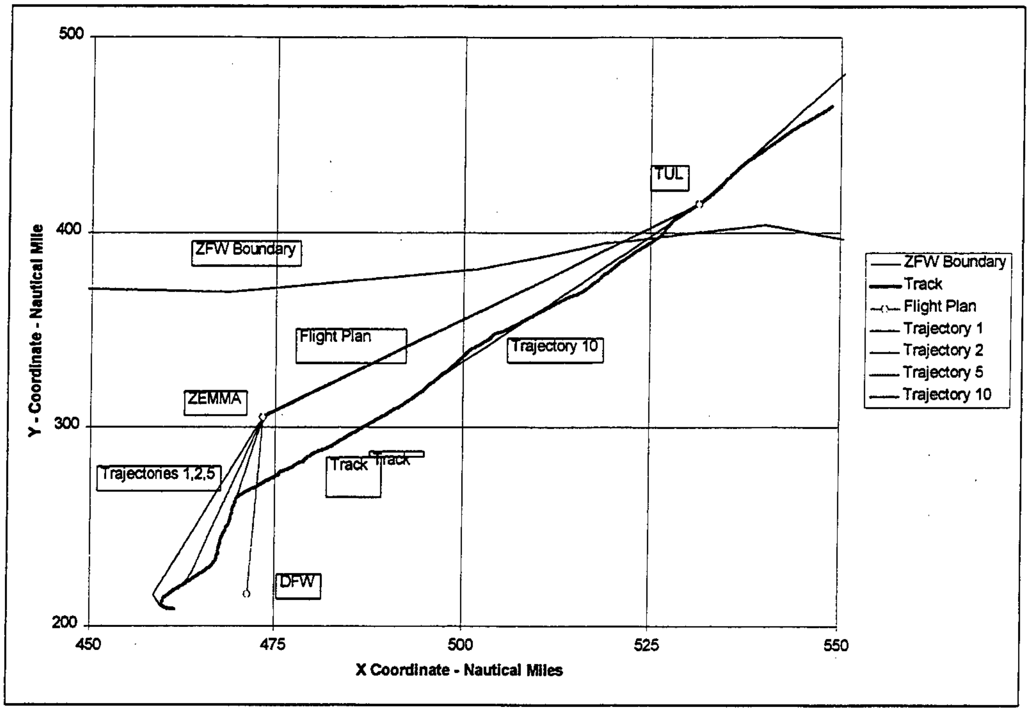

Figure 4.2-3: XY Track and Trajectories

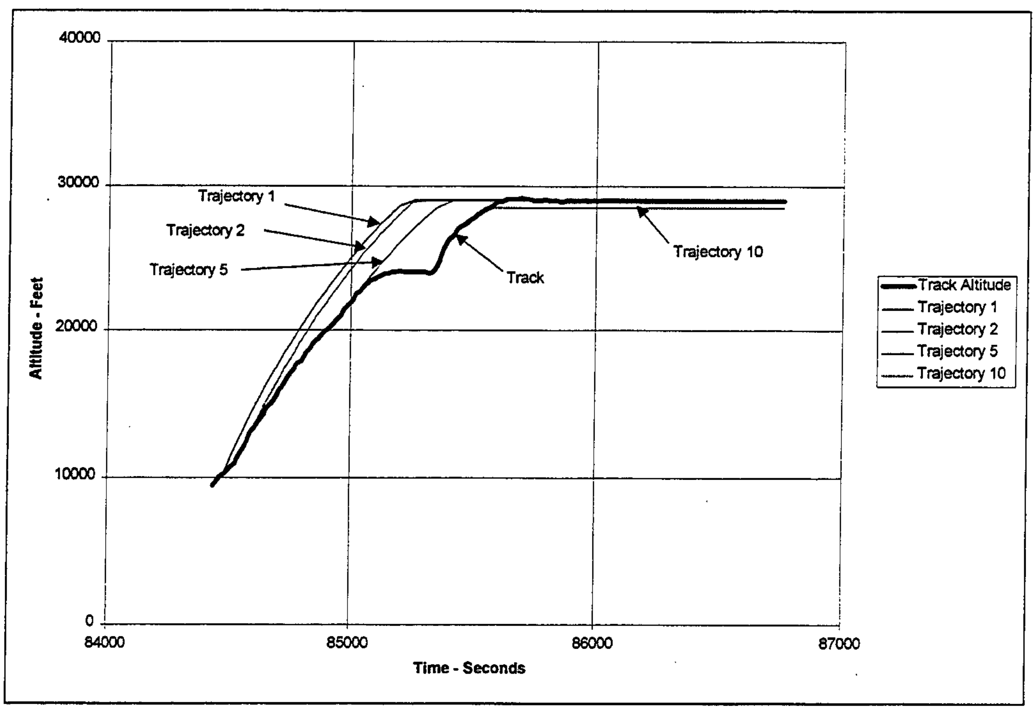

Figure 4.2-4: Altitude and Trajectory

Table 4.2-1: Trajectory Metrics (1 of 2)[9]

Sample Time	Traj No	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
84480	1	84480	0	0.00	0.01	0.00
			300	2.70	4.90	-2028.92
			600	3.84	4.77	-3188.23
			900	7.82	14.83	-3314.00
			1200	14.03	9.07	86.00
			1500	18.40	7.07	-14.00
84600	2	84600	0	0.00	0.00	0.00
			300	2.45	1.93	-1852.62
			600	4.67	8.12	-3975.92
			900	12.21	14.03	-1212.00
			1200	15.64	7.50	-12.00
			1500	19.43	4.63	-12.00
84720	3	84720	0	0.00	0.00	100.00
			300	0.48	0.07	-1088.23
			600	0.59	12.14	-4848.54
			900	5.07	10.70	-7.00
			1200	6.16	7.08	-7.00
84840	4	84839	0	-0.10	0.00	-25.74
			300	1.14	4.61	-1788.82
			600	8.53	13.93	-1912.00
			900	8.30	8.11	-12.00
			1200	11.19	5.76	-12.00
84960	5	84960	0	0.00	0.00	0.00
			300	0.77	9.81	-3105.08
			600	6.13	11.99	-502.00
			900	6.25	7.35	-102.00
			1200	7.13	3.77	-2.00
85080	6	85080	0	0.00	-0.01	0.00
			300	4.61	14.54	2300.00
			600	16.67	9.41	5700.00
			900	23.88	7.24	5600.00

[9] In this chart, longitudinal and lateral error are reported in hundredths of nautical miles, and the vertical error is reported in hundredths of feet. The precision of the input HCS altitude data is reported to the nearest 100 feet, the apparent difference is simply an artifact of the track report processing.

Table 4.2-1: Trajectory Metrics (2 of 2)

Sample Time	Traj No	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
85200	7	85200	0	0.00	0.00	100.00
			300	2.49	0.96	3800.00
			600	5.64	-0.45	5000.00
			900	10.13	1.09	5000.00
85320	8	85320	0	0.00	-0.01	-100.00
			300	-1.84	0.19	408.31
			600	-1.96	0.95	-10.00
85440	9	85440	0	0.00	-0.01	100.00
			300	-1.13	-1.42	-11.00
			600	0.64	1.07	-11.00
85560	10	85559	0	-0.11	0.00	0.00
			300	2.32	0.00	400.00
			600	5.44	0.98	500.00
85680	11	85680	0	0.00	0.00	100.00
			300	1.52	2.29	0.00
85800	12	85800	0	0.00	0.00	0.00
			300	0.80	1.19	0.00
85920	13	85920	0	0.00	0.00	0.00
86040	14	86040	0	0.00	0.00	0.00
86160	15	86160	0	0.00	0.00	0.00

4.3 Results

After running CTAS (i.e. Daisy View Release 990105) with the seven hour scenario file defined in Section 4.1, a total of 32,162 trajectories were sampled out of 352,742 trajectories. The sampled trajectories were from 2168 flights. Therefore, each one of these flights on average had 14.8 trajectories analyzed. The average duration of extracted trajectories is approximately 27 minutes with a standard deviation of nine minutes. This is lower than the actual trajectory duration built by CTAS, due to the recording process adapted in collecting these trajectories. If a trajectory exists, it is recorded at each HCS track report update (i.e. around every 12 seconds), but the actual duration recorded is only up to 32.5 minutes into the future. This is explained in more detail in Sections 2.5.1 and 4.1. The sampling process reduced the trajectory to the portion where both HCS track data and the predicted trajectory overlap in time, so the duration of the trajectory actually analyzed was reduced to approximately 22 minutes on average with a standard deviation of 11 minutes.

To set the context of the study as defined in Section 2.6.2.1, the counts of the event areas illustrated in Figure 2.6-1 are listed in Table 4.3-1 below. Referring to Figure 2.6-1, the ratio of area "a" to the sum of areas "a" and "c" defines the DST's fraction of valid flights with sampled trajectory prediction. For CTAS, 94.5 percent of the valid aircraft flights had sampled trajectory prediction.

Table 4.3-1: Valid Track and Trajectory Counts for CTAS Scenario

	Valid HCS Flight Data	Insufficient Valid HCS Flight Data	Total Flights With Trajectories
Trajectory	2168 (a)	331(b)	2499 (a +b)
Insufficient Trajectory	127 (c)		
Total Valid Flights	2295 (a + c)		

As defined in Section 2.6.2.2, another statistic useful in setting the context of the study estimates the trajectory prediction coverage over the track time analyzed. For CTAS, each analyzed flight had an average of 87 percent of prediction coverage with a standard deviation of 17.1 percent. Referring to Figure 4.3-1 and the Quantiles in Table 4.3-2, the distribution is relatively spread out with around a 99 percent of prediction coverage value at the ninetieth percentile to a 62 percent of prediction coverage value at the tenth percentile. The distribution forms a 95 percent confidence interval around the mean between 86.3 to 87.7. The maximum ratio of prediction coverage for CTAS was 99.5 percent and the minimum was 4.3 percent.

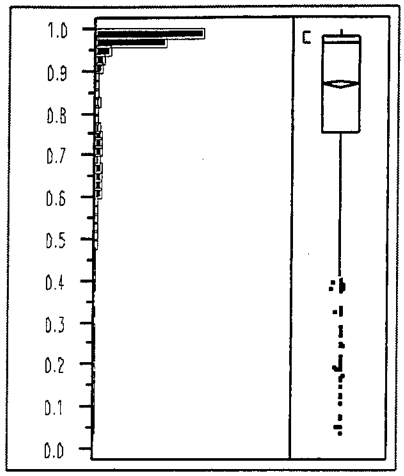

Figure 4.3-1: CTAS's Distribution of Ratio of Coverage Statistic

Table 4.3-2: Quantile Table of Ratio of Prediction Coverage

Quantile Labels	Percentiles	Values
Maximum	100.0%	0.99514
	99.5%	0.99357
	97.5%	0.99121
	90.0%	0.98780
Quartile	75.0%	0.98253
Median	50.0%	0.96952
Quartile	25.0%	0.75380
	10.0%	0.61926
	2.5%	0.45230
	0.5%	0.16663
Minimum	0.0%	0.04225

As described in Section 2.6.2.3, another descriptive value that defines the context of the analysis is the age of the trajectory at the look ahead time of zero. For CTAS, trajectories are built every time the HCS track positions are reported (every 12 seconds). There are situations where trajectories are older, including instances where CTAS did not update the trajectory or when the HCS did not supply a track exactly every 12 seconds. This study's sampled CTAS trajectories have an average trajectory age of approximately 14.6 seconds with a standard deviation of 57 seconds.

As discussed above, CTAS builds trajectories approximately every 12 seconds. The build time in seconds combined with the aircraft identifier string and HCS CID should uniquely represent a particular trajectory. However, there are instances that an aircraft has multiple trajectories with common build times. It was determined that the x and y coordinates within these multiple trajectories were close, but not identical. With the first recorded trajectory often being the correct one, the altitudes did vary significantly. Since these multiple instances occurred infrequently, it was decided to accept the first trajectory, and discard the others. Out of the 352,742 recorded trajectories in this study only 1.8 percent had more than one trajectory with a common build time.

The actual trajectory metrics and sampling process is defined in Section 2.5.1. For this seven hour ZFW scenario, 127,460 samples were taken against the 32,162 trajectories discussed above. Each sample consisted of spatial prediction error measurements including horizontal error, lateral error, longitudinal error, and vertical error. These measures are reported as a function of different look ahead times from zero to 30 minutes in the future, so the trajectory prediction performance includes the spatial prediction errors partitioned by look ahead time. As a review, look ahead time is the predicted time into the future measured from the sample start time for that particular flight. In this study increments of five minutes were used up to a look ahead time of 30 minutes into the future. In other words, if the flight had both a sampled trajectory and sufficient HCS track reports for the full range of time overlap, error measurements would be calculated at zero, five, 10, 15, 20, 25 and 30 minutes into the future for each sample at the current time.

Table 4.3-3 lists the types of statistical analyses that were performed on each of the identified factors. The analyses include either descriptive statistics in which simple tables are presented, inferential statistics in which hypothesis testing of the means and variances were performed, or both. This table also lists whether graphical information was presented with references to the appropriate section number. Inferential statistics and graphical plots (i.e. histograms and quantile tables) were calculated for a subset of the available look ahead times, including zero, 600, 1200, and 1800 seconds. The signed values of the error metrics (e.g. average lateral error) were used for these more exhaustive inferential techniques, since the sample mean acts as a measure of the bias of the trajectory predictions and the standard deviation as a measure of the uncertainty. The absolute value statistics (e.g. average absolute value of lateral error), which are also a useful measure of the uncertainty, have been included in the descriptive statistics reported in Appendix A.2.

Table 4.3-3: CTAS Analysis Summary

Factor For Samples at All Altitudes / Above FL180	Descriptive Statistics	Inferential Statistics	Histograms / Quantiles	Section Number
Look Ahead Time	Yes	Yes	Yes	4.3.1
Flight Type	Yes	Yes	No	4.3.2
Phase of Flight Horizontal	Yes	Yes	No	4.3.3
Phase of Flight Vertical	Yes	Yes	No	4.3.4

4.3.1 Analysis of Look ahead time on Trajectory Accuracy

The main factor analyzed in this study was look ahead time, defined in Section 2.2.3.3. One would expect look ahead time to have a statistically significant effect on performance, but the magnitude of the effect is also of interest. A complete table of the spatial prediction error statistics are presented at the look ahead times of zero, 300, 600, 900, 1200, 1500, and 1800 seconds (i.e. zero to 30 minutes) in Appendix A.2. The focus of the following analysis is on the signed error for lateral, longitudinal, horizontal, and vertical errors at the look ahead times of zero, 600, 1200, and 1800 seconds. This analysis includes an example set and summary results of several tables of statistical information provided by the SAS-JMP Software package (SAS Institute, 1995). They are used to evaluate the error data categorized by look ahead time and in the later sections by horizontal and vertical phase of flight. Complete tables for the CTAS data are provided in Appendix A.2. The tables present test results for unequal variance including the Levene Test and the Welch Anova Test. They also include a pairwise means comparison, referred to as the Tukey-Kramer HSD Test. Graphical plots present a comparison of means with

a quantile box, a plot of the means at look ahead time versus error, and a plot of means using the Tukey-Kramer criteria.

4.3.1.1 Samples at all altitudes

The sample variance of the horizontal error from the four look ahead times are compared first by a Levene Statistical Test (Neter, 1996). Referring to Table 4.3-4, this statistical test determines if the hypothesis of equal variances can be rejected. The hypothesis can be rejected in this case, since the variances are significantly different. From Table 4.3-4, the variance of horizontal error is increasing as the look ahead time increases.

Table 4.3-4: Tests for Equal Variances and Tests for Equal Means

Tests that the Variances are Equal (Horizontal Error)[10]				
Level (seconds)	Count	Std Dev (nm)	MeanAbsDif to Mean (nm)	MeanAbsDif To Median (nm)
0	32609	0.85	0.25	0.20
600	21908	4.95	3.45	3.17
1200	12921	8.11	5.81	5.38
1800	6657	11.22	8.21	7.56
Test	F Ratio	Deg of Freedom	DF Den	Prob>F
Levene	11959.59	3	74091	0.0000
Welch Anova testing Means Equal, allowing Std's Not Equal				
	F Ratio	Deg of Freedom	DF Den	Prob>F
	10866.43	3	18479	0.0000

Next, the sample mean for each look ahead time is compared. Referring to Table 4.3-4, the Welch test is applied which compares distributions with different variances and sample sizes. It tests whether all the group means are equal. For the horizontal error at different look ahead times, the Welch Test provides evidence to reject the hypothesis that these mean errors are equal. In Figure 4.3-2, diamonds are drawn around each mean representing the 95 percent confidence interval (in this case, the diamonds are flat and look more like heavy lines due to the large range between the group means). These confidence intervals show an increase in the average horizontal error from zero to 1800 seconds look ahead time of approximately 10.6 nautical miles, from 0.3 to 10.9 nautical miles.

[10] Mean Absolute difference to mean and median are intermediate calculations in the Levene Test described in the Appendix A.0.

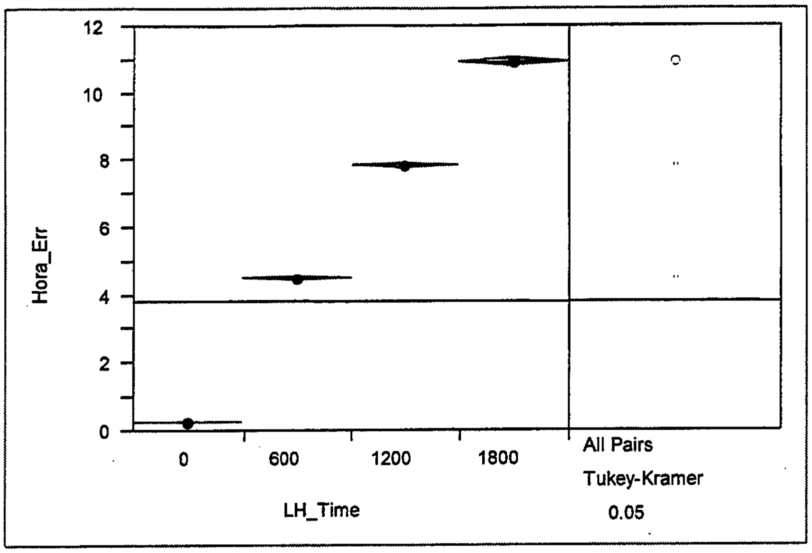

Figure 4.3-2: Sample Mean Comparison of Horizontal Error at Four Look Ahead Times[11]

The lower portion of Table 4.3-5 presents the results of a third statistical test, called the Tukey-Kramer Test, that compares all pairs of means and holds the Type I error at 0.05 for the entire test. It has the exact Type I error if the sample sizes are equal, and is conservative if they are not, which is the case in this study (Devore, 1987). The horizontal error at the four look ahead times is significantly difference between all pairs. The Tukey-Kramer Test provides a distance referred to as the Least Significant Difference (LSD)[12] that can be subtracted from the absolute difference of each pair of means. If the result is positive, the absolute difference of the means is greater than LSD, and the pair of means is significantly different. If the result is negative, the LSD is greater, and the pair is not significantly different. The upper portion of Table 4.3-5 lists the pairwise differences of the sample means for the various look ahead times. All these pairwise comparisons of the means of the horizontal error at the different look ahead times were significant.

The right side of Figure 4.3-2 presents a graphical form of the Tukey-Kramer Test. Too small to be drawn in some cases, it constructs circles around the sample means with a diameter approximately equal to the 95 percent confidence interval. However, this interval is expanded to account for the comparison of all pairs. In short, if the circles overlap the means are not considered significantly different; if they do not overlap, the means are considered significantly different. The circles drawn in Figure 4.3-2 are not overlapping at all, illustrating the numerical results that all the means are different.

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[11] Normally, the height of the diamond is the length of the confidence interval and the width is proportional to the sample size. In this study, the width has been set equal for all sample sizes.

[12] LSD is proportional to the square root of the sum of the squared product of q* and the standard error of both means being compared. The q* value is a quantile similar to the t value of a Student t distribution but expanded to account for the alpha being held constant for the entire set of comparisons (SAS Institute, 1995).

Table 4.3-5: Statistical Comparison of All Means (Horizontal Error)

Means Comparisons				
Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.0000	3.1195	6.4127	10.6661
1200	-3.1195	0.0000	3.2932	7.5466
600	-6.4127	-3.2932	0.0000	4.3534
0	-10.6661	-7.5466	-4.3534	0.0000

Comparisons for all pairs using Tukey-Kramer HSD				
q* = 2.56909	Alpha=0.05			
Abs(Dif)-LSD	1800	1200	600	0
1800	-0.2454	2.9059	6.2146	10.4757
1200	2.9059	-0.1761	3.1361	7.3994
600	6.2146	3.1361	-01353	4.1298
0	10.4757	7.3994	4.1298	-0.1109
Positive values show pairs of means that are Significantly different.				

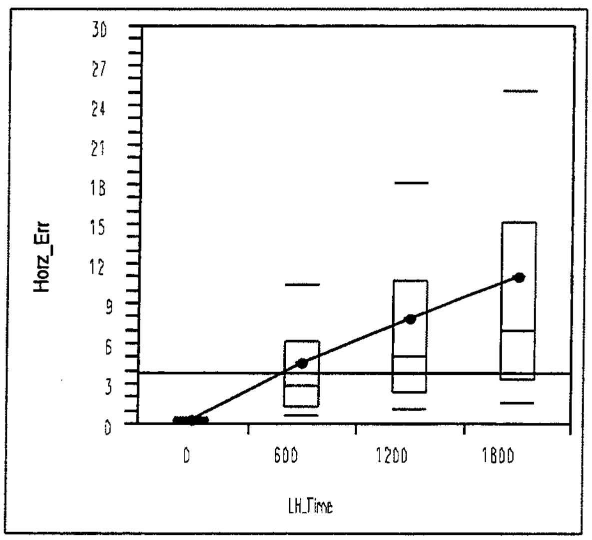

Figure 4.3-3: Quantile / Mean Comparison of Horizontal Error Vs. LH

In summary, the mean horizontal error is statistically significant at the look ahead times of zero, 600, 1200, and 1800 seconds. Referring to Figure 4.3-3, the sample means are also increasing as the look ahead time (LH) increases, ranging from a sample mean of 0.28 nautical miles at look ahead zero to 10.94 at 1800 seconds (i.e. 30 minutes). The mean of all observations is drawn as a horizontal line across the entire plot. The median is also increasing from 0.14 nautical miles at zero look ahead time to 6.9 at 1800 seconds. The horizontal lines in Figure 4.3-3's boxes correspond to the 10, 25, 50, 75, and 90 percentiles of the distribution of the sampled horizontal

errors, respectively[13]. Tested statistically with the Levene Test earlier, the box ranges illustrate that the spread of the horizontal error is also increasing as the look ahead time increases.

The analysis continues by examining the lateral, longitudinal, and vertical errors using the same methods described for the horizontal error. The results are summarized in Table 4.3-6 and the means comparisons of the lateral, longitudinal and vertical errors are shown in Figures 4.3-4 through 4.3-6. The descriptive statistics of the absolute values of the four errors are tabulated in Appendix A.2.

Table 4.3-6: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	Yes	Yes	Yes-all	Means and variance increase with look ahead time (LH).
Lateral	Yes	Yes	Yes-5of6	Only LH 1200 versus LH 1800 not different. Means (all positive) and variance increase with LH except at LH 1200 and 1800.
Long.	Yes	Yes	Yes-all	Means and variance increase with LH.
Vertical	Yes	Yes	Yes-all	Means all negative and different. Means and variance increase with LH.

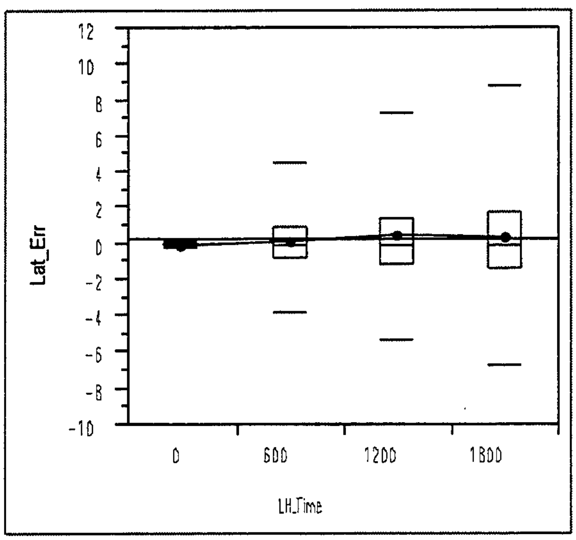

Figure 4.3-4: Quantile / Mean Comparison of Lateral Error Vs. LH

13 The percentiles illustrated in Figure 4.3-3 as horizontal lines and box ends are described in detail in Appendix A.0.

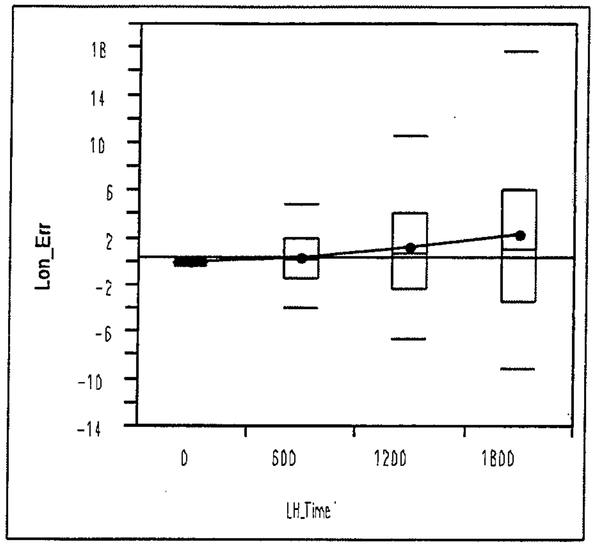

Figure 4.3-5: Quantile / Mean Comparison of Longitudinal Error Vs. LH

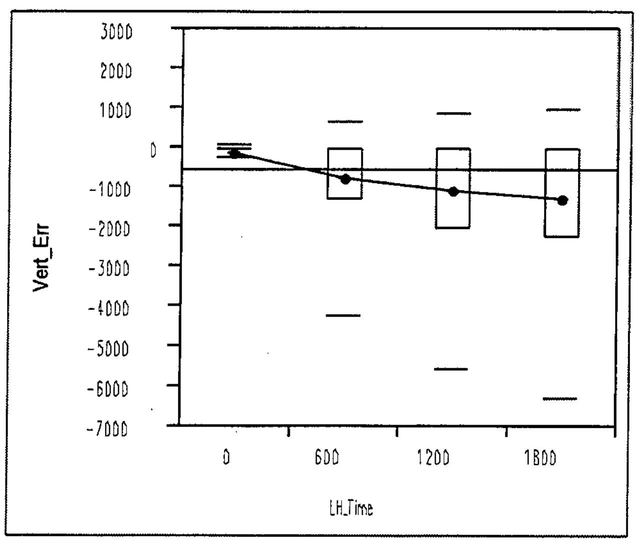

Figure 4.3-6: Quantile / Mean Comparison of Vertical Error Vs. LH

4.3.1.2 Samples at altitudes above 18,000 feet

For samples at altitudes above 18,000 feet only, the results are summarized in Table 4.3-7. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-7: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	Yes	Yes	Yes-all	Means and variance increase with LH.
Lateral	Yes	Yes	Yes-5of6	Only LH 1200 versus LH 1800 are not different. Variance increases with LH.
Long.	Yes	Yes	Yes-5of6	Only LH 1200 versus LH 1800 are not different. Mean and variance increases with LH.
Vertical	Yes	Yes	Yes-5of6	Means negative. Only LH 1200 versus LH 1800 are not different. LH 600 largest error. Variance increases with LH.

4.3.1.3 Discussion of the effect of look ahead time

In general, look ahead time does have a significant effect on each sample mean, which increases as the look ahead time increases. For horizontal error, the sample means increase over 10 nautical miles from zero to 1800 seconds (i.e. 30 minutes) look ahead time. The variance of the horizontal error also increases with look ahead time with a standard deviation ranging from around one nautical mile to over 11 nautical miles. Lateral and longitudinal errors are exact orthogonal components of the horizontal error, but the dominant source of horizontal error is the longitudinal error. Referring to Figures 4.3-4 and 4.3-5, the average lateral error ranges from zero to 0.46 nautical miles, and the longitudinal error ranges from slightly less than zero to around 2.4 nautical miles. The magnitude increases substantially when looking at the absolute values of the lateral and longitudinal errors. Referring to Appendix A.2, the absolute value (i.e. unsigned) means of lateral error range from 0.1 to 4.9 nautical miles from zero to 30 minutes look ahead time. The absolute value means of longitudinal error range from 0.2 to 8.1 nautical miles from zero to 30 minutes look ahead time. The vertical error mean and variance also increases for zero to 30 minutes look ahead time from –98 to –1270 feet and 790 to 3870 feet, respectively.

For the most part, the analysis of samples above 18,000 feet are consistent with the all altitudes analysis except for vertical error which seems to peak around 10 minutes (600 seconds) look ahead time at around –280 feet and actually gets less at 30 minutes to around –130 feet. The causes for this effect have been left for future analysis.

4.3.2 Analysis of Flight Type on Trajectory Accuracy

Flight type is determined by examining the origin and destination airports in a flight plan. The flight type includes four possible levels referred to as overflight, departure, arrival, and internal. Overflight is an aircraft whose origin and destination are outside the particular center's airspace, ZFW in this case. Departures leave an airport inside the center, and arrivals land at an airport inside the center. The internals include flights that have both origin and destination airports inside the center.

The analysis that follows examines whether the means of the trajectory prediction errors of the flight types are significantly different at the four look ahead times of zero, 600, 1200, and 1800 seconds. This analysis focuses on these four look ahead times and flight types against the signed lateral, longitudinal, vertical, and horizontal errors. Appendix A.2 contains a more complete set of look ahead times and also includes the descriptive statistics on the unsigned or absolute values of the errors. Figures 4.3-7 through 4.3-10 plot the sample means for each flight type as a function of look ahead time (LH) where OVR denotes overflights, ARR denotes arrivals, DEP denotes departures, and INR denotes internals.

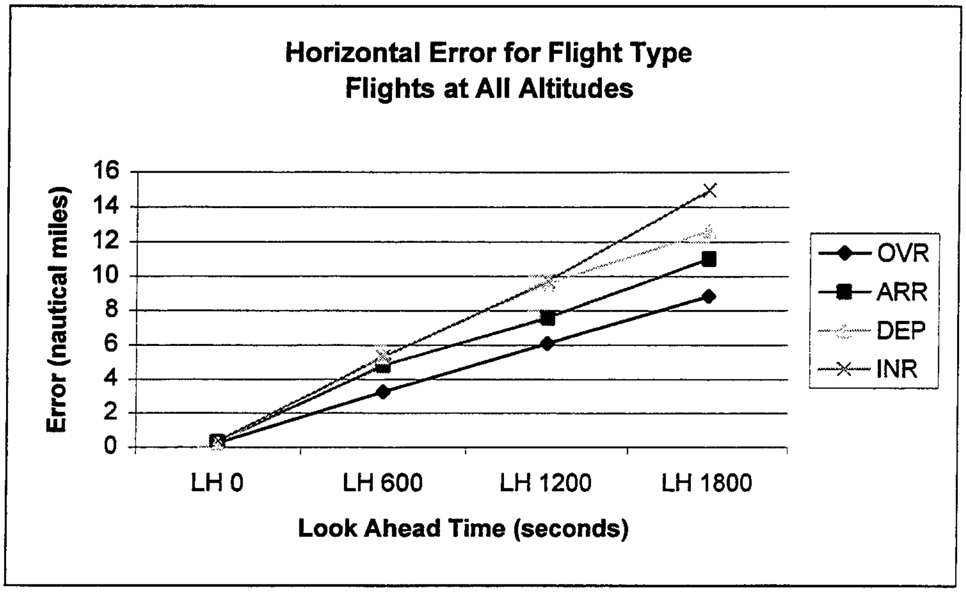

Figure 4.3-7: Sample Means for Horizontal Error per Flight Type and LH

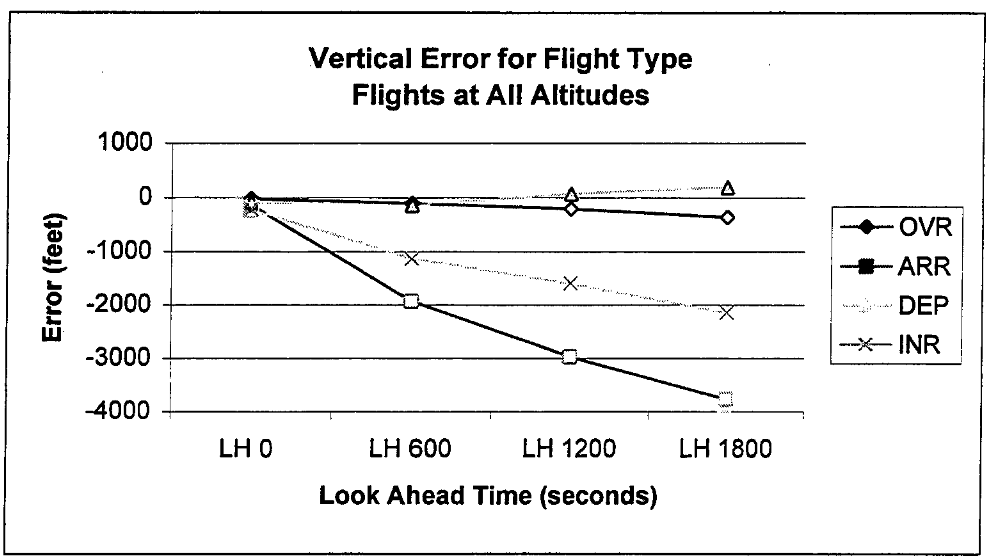

Figure 4.3-8: Sample Means for Vertical Error per Flight Type and LH

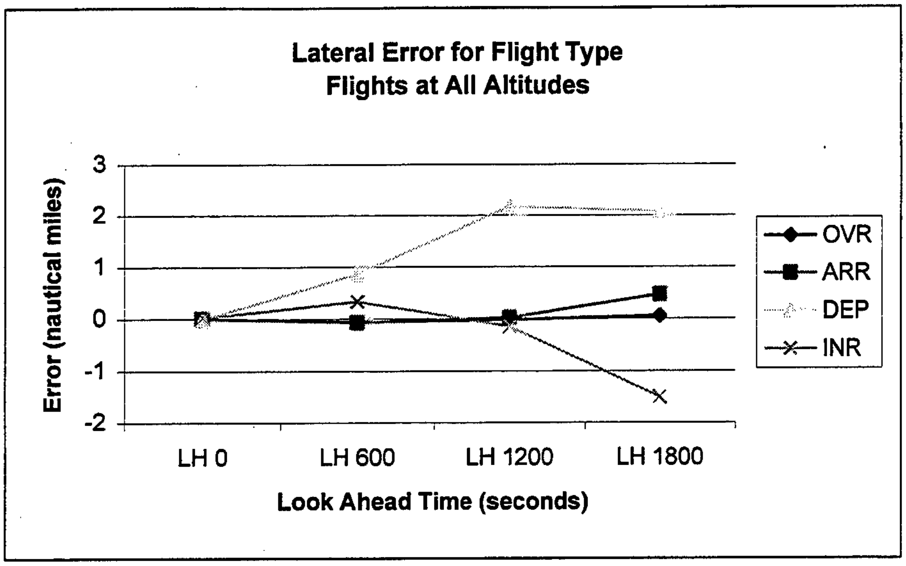

Figure 4.3-9: Sample Means for Lateral Error per Flight Type and LH

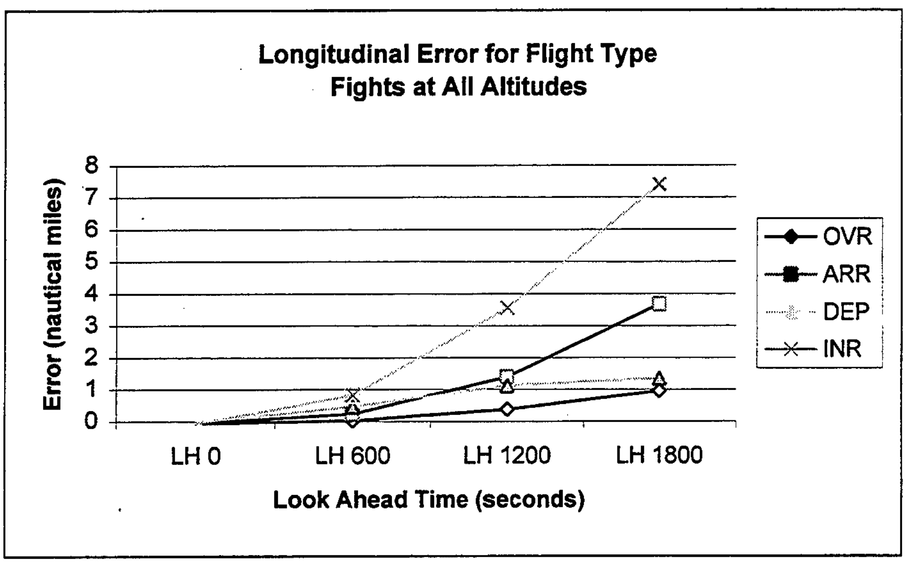

Figure 4.3-10: Sample Means for Longitudinal Error per Flight Type and LH

4.3.2.1 Samples at all altitudes

The results are summarized in Table 4.3-8. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-8: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-4of6	Internals versus arrivals and departures versus overflights are not different. Internals/arrivals have the largest error.
Lateral	0	Yes	Yes	Yes-1of6	Only internals versus departures significantly different.
Long.	0	Yes	Yes	Yes-1of6	Only internals versus departures different.
Vertical	0	Yes	Yes	Yes-all	All means are significantly different statistically but the magnitude is only a few hundred feet.
Horizontal	600	Yes	Yes	Yes-5of6	Internals versus departures not different.
Lateral	600	Yes	Yes	Yes-5of6	Only arrivals and overflights not different.
Long.	600	Yes	Yes	Yes-all	Maximum range between means 0.8 nm.
Vertical	600	Yes	Yes	Yes-5of6	Departures versus overflights not different. Arrivals having largest mean but internals with largest variance.
Horizontal	1200	Yes	Yes	Yes-5of6	Only internals versus departures are not different.
Lateral	1200	Yes	Yes	Yes-3of6	Only departures (with a larger error) are significantly different from the others.
Long.	1200	Yes	Yes	Yes-5of6	Only departures versus arrivals are not different. Internals have largest error.
Vertical	1200	Yes	Yes	Yes-all	Arrivals have largest error and departures smallest.
Horizontal	1800	Yes	Yes	Yes-all	Overflights have the smallest horizontal error, while internals have the largest error.
Lateral	1800	Yes	Yes	Yes-5of6	Only arrivals and overflights not different
Long.	1800	Yes	Yes	Yes-5of6	Only departures versus overflights are not different. Internals have largest error.
Vertical	1800	Yes	Yes	Yes-all	Arrivals have largest error.

4.3.2.2 Samples at altitudes above 18,000 feet

The results are summarized in Table 4.3-9. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-9: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-3of6	Only internals versus others are significantly different.
Lateral	0	Yes	Yes	Yes-3of6	Only internals versus others are significantly different.
Long.	0	Yes	Yes	Yes-4of6	Departures versus overflights and arrivals versus overflights are not different.
Vertical	0	Yes	Yes	Yes-3of6	Only internals versus others are different. Internals being slightly larger and positive on average while the others are negative.
Horizontal	600	Yes	Yes	Yes-all	Internals have largest error and overflights smallest.
Lateral	600	Yes	Yes	Yes-3of6	Departures (larger) different than others.
Long.	600	Yes	Yes	Yes-5of6	Only arrivals versus overflights not different. Internals have largest error.
Vertical	600	Yes	Yes	Yes-5of6	Internals versus departures are not different. Arrivals have largest error.
Horizontal	1200	Yes	Yes	Yes-5of6	Arrivals versus overflights are not different. Internals have the largest error
Lateral	1200	Yes	Yes	Yes-3of6	Departures have the largest mean and are significantly different from the others.
Long.	1200	Yes	Yes	Yes-5of6	Only overflights versus arrivals are not different. Internals have the largest mean.
Vertical	1200	Yes	Yes	Yes-all	All significantly different, but arrivals have much larger mean error and internals have much larger variance relative to the others.
Horizontal	1800	Yes	Yes	Yes-4of6	Arrivals versus overflights and departures and internals are not different. Departures and internals have the larger error.
Lateral	1800	Yes	Yes	Yes-4of6	Departures are different from others and overflights versus internals are different as well.
Long.	1800	Yes	No	No	Only variance is different, with internals having the largest variance.
Vertical	1800	Yes	Yes	Yes-5of6	Departures versus internals not different. Arrivals largest mean and internals largest variance.

4.3.2.3 Discussion of the effect of flight type

In general, flight type has a significant effect on trajectory performance. For horizontal error, overflights have the least errors as look ahead time increases, while internals have the most error ranging from 0.3 to 15 nautical miles from zero to 30 minutes look ahead time, respectively. For vertical error, arrivals seem to have the greatest mean as look ahead time increases, but internals have the largest standard deviation overall. At the lower look ahead times, the vertical error sample means vary little between flight types, but as look ahead time increases they spread out in general very quickly. For example, at look ahead time of 600 seconds or 10 minutes, the arrivals have a mean vertical error of –1923 feet while the overflights have –106 feet mean vertical error.

As far as lateral error, only departures seem to increase considerably as look ahead time increases from –0.01 to 2 nautical miles from 0 to 1800 seconds look ahead time, respectively. Longitudinal error on the other hand does increase as look ahead increases from –0.08 to 7.4 nautical miles on average.. For longitudinal error sample means, the internals dominate from around zero to 6 nautical miles larger than the other flight types on average.

4.3.3 Analysis of Horizontal Phase of Flight on Trajectory Accuracy

Horizontal phase of flight is calculated for each HCS track report and extracted for the trajectory accuracy measurements. This factor is categorized into two levels: straight or turn. The PHASE_D program that detects turns, described in Section 2.4.6.1, had its parameters set to protect against noise in the track data. As a result, rapid turns are detected but shallow turns may be missed. A turn is determined by a nine degree angle (or greater) generated by the two segments drawn from the previous position to the current position and the current position to the next position report.

The analysis that follows examines whether the mean of the trajectory prediction error at the two horizontal phases of flight are significantly different statistically at the four look ahead times of zero, 600, 1200, and 1800 seconds. This analysis will focus on these four look ahead times and two phases of flight against the signed lateral, longitudinal, vertical, and horizontal errors. Appendix A.2 contains a more complete set of look ahead times and also includes the descriptive statistics on the unsigned or absolute values of the errors. The following Figures 4.3-11 to 4.3-14 plot the sample means for each horizontal phase of flight as a function of look ahead time (LH), where STR denotes straight and TRN denotes turning.

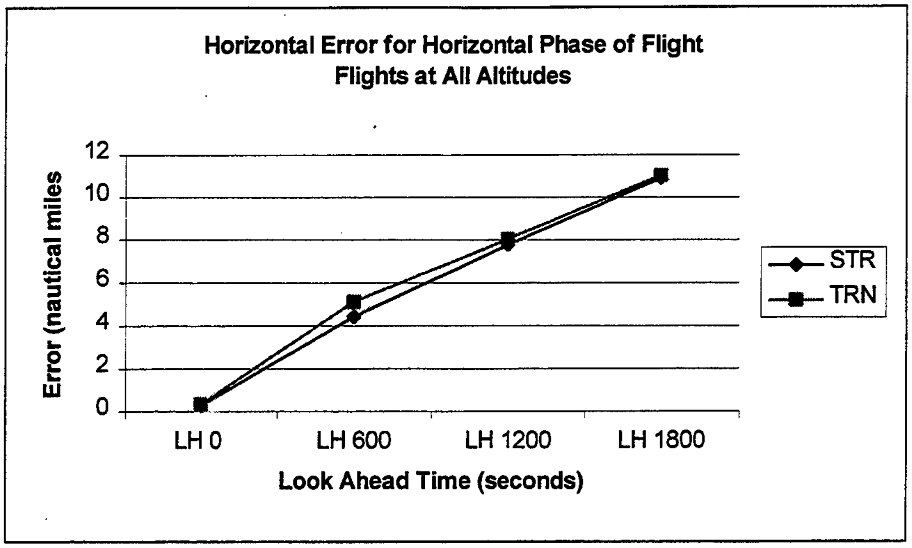

Figure 4.3-11: Sample Means for Horizontal Error per Horizontal Phase of Flight and LH

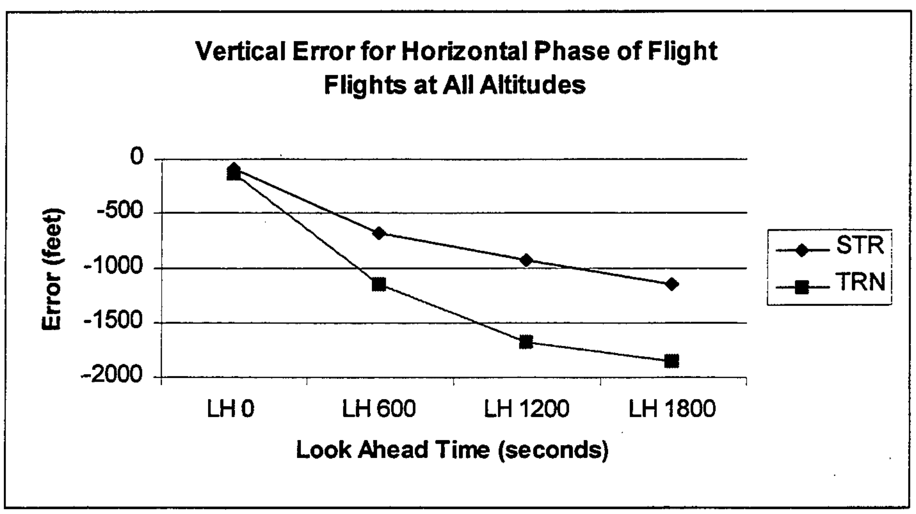

Figure 4.3-12: Sample Means for Vertical Error per Horizontal Phase of Flight and LH

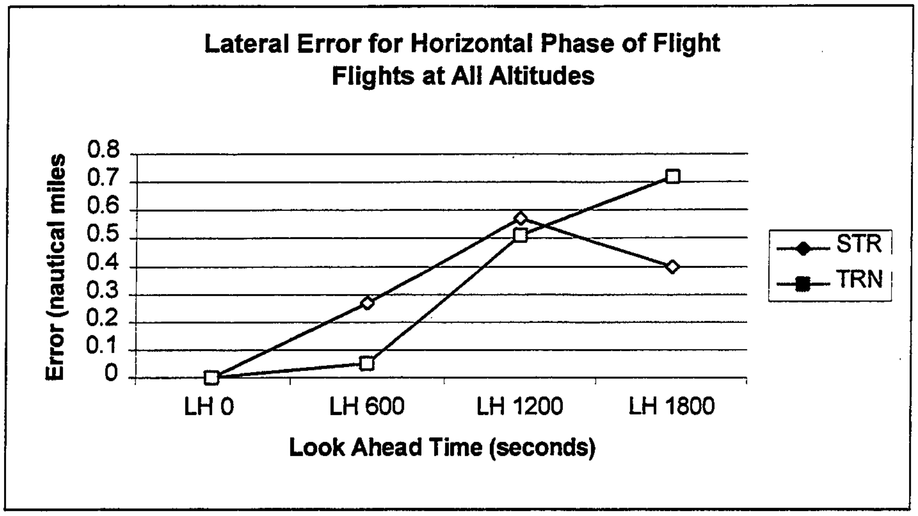

Figure 4.3-13: Sample Means for Lateral Error per Horizontal Phase of Flight and LH

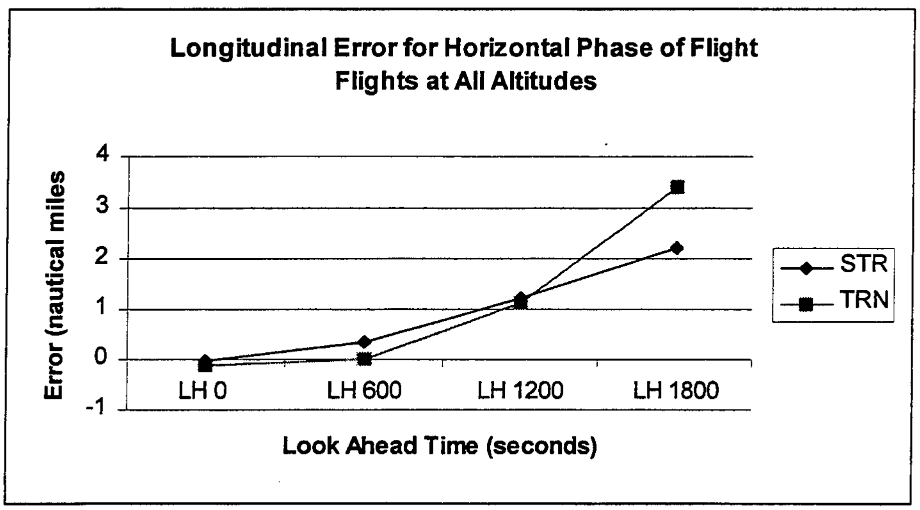

Figure 4.3-14: Sample Means for Longitudinal Error per Horizontal Phase of Flight and LH

4.3.3.1 Samples at all altitudes

The results are summarized in Table 4.3-10. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-10: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes	Means all different. Turns are larger by 0.07 nautical miles.
Lateral	0	Yes	No	No	Variance is different only.
Long.	0	Yes	Yes	Yes	Means both negative with turns larger by 0.07 nautical miles.
Vertical	0	Yes	Yes	Yes	Means both negative and different. Turns larger by 37 feet.
Horizontal	600	Yes	Yes	Yes	Turns larger by 0.7 nautical mile.
Lateral	600	Yes	Yes	Yes	Straight is larger by 0.22 nautical miles.
Long.	600	Yes	Yes	Yes	Straight is larger by 0.34 nautical miles.
Vertical	600	Yes	Yes	Yes	Turns larger by 460 feet.
Horizontal	1200	No	No	No	Not significantly different.
Lateral	1200	No	No	No	Not significantly different.
Long.	1200	Yes	No	No	Only variance significantly different.
Vertical	1200	Yes	Yes	Yes	Turns larger by 740 feet.
Horizontal	1800	No	No	No	Not significantly different.
Lateral	1800	No	No	No	Not significantly different.
Long.	1800	No	Yes	Yes	Turns larger around 1.2 nautical miles.
Vertical	1800	Yes	Yes	Yes	Turns larger by 700 feet.

4.3.3.2 Samples at altitudes above 18,000 feet

The results are summarized in Table 4.3-11. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-11: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes	Turns larger by 0.12 nautical miles.
Lateral	0	Yes	No	No	Only variance significantly different.
Long.	0	Yes	Yes	Yes	Turns larger by 0.09 nautical miles.
Vertical	0	Yes	Yes	Yes	Different but turns larger by only 30 feet.
Horizontal	600	Yes	Yes	Yes	Turns larger by 1 nautical mile.
Lateral	600	Yes	No	Yes	Only variance significantly different. T-K Test does provide evidence that means are different but Welch Test with p-value of 0.08 has more power to differentiate.
Long.	600	Yes	Yes	Yes	Turns larger by 0.23 nautical miles.
Vertical	600	Yes	Yes	Yes	Turns larger by 500 feet.
Horizontal	1200	No	No	No	Not significantly different.
Lateral	1200	No	No	No	Not significantly different.
Long.	1200	No	No	No	Not significantly different.
Vertical	1200	Yes	Yes	Yes	Turns larger by 700 feet.
Horizontal	1800	Yes	No	No	Only variance significantly different.
Lateral	1800	No	No	No	Not significantly different.
Long.	1800	No	No	No	Not significantly different.
Vertical	1800	Yes	Yes	Yes	Turns larger by 500 feet.

4.3.3.3 Discussion of the effect of Horizontal Phase of Flight

In general for horizontal error, the phase of flight in the horizontal dimension is significant only at the lower look ahead times. As the look ahead times get larger, the difference between samples at turns or straight paths becomes insignificant. However, for vertical error the difference is significant and consistently higher at all look ahead times for turns compared to straight samples. It also becomes larger as look ahead time increases. For both the horizontal and vertical dimensions, the differences between turning and straight samples is still rather small (i.e. less one nautical mile for horizontal error and 700 feet for vertical error). These small magnitudes may be caused by the insensitivity in characterizing a turn. The track points are only evaluated at large turns (around nine degrees) to protect against noise in the data, making it less powerful in detecting small turns. There has also been some discussion on the need for analysis a small distance before and after the actual turn. The current technique for determining an aircraft is turning is not sufficiently robust in filtering out the noise of the HCS track reports nor can it examine the straight path around the turn. As a result, the statistical analysis of the effect of turns should be interpreted advisedly and the algorithm will be revisited in the future.

4.3.4 Analysis of Vertical Phase of Flight on Trajectory Accuracy

Similar to horizontal phase of flight, vertical phase of flight is calculated for each interpolated HCS track report and extracted for the trajectory accuracy measurements. Vertical phase of flight is categorized into three categories: level, ascending, or descending. The track points are only labeled as climbing or descending for reasonably large climbs and descents to protect against noise in the position data, but this also prevents detection of low rate climbs and descents (i.e. smaller than 900 feet per minute). A climb or descent is determined by calculating the difference in altitude between the current interpolated track position and the next track position. If the absolute difference is less than 150 feet, the current position of the aircraft is considered in level flight, otherwise the aircraft is in a climb or descent depending on the direction up or down. Since the track positions are interpolated at 10 second intervals, the required gradient for the climbing or descending aircraft is greater than or equal to 15 feet per second or 900 feet per minute. The phase of flight algorithm is described in detail in Section 2.4.6.

The analysis that follows examines whether the mean of the trajectory prediction error at the three vertical phases of flight are significantly different statistically at the four look ahead times of zero, 600, 1200, and 1800 seconds. This analysis focuses on these four look ahead times and three phases of flight against the signed lateral, longitudinal, vertical, and horizontal errors. Appendix A.2 contains a more complete set of look ahead times and also includes the descriptive statistics on the unsigned or absolute values of the errors. The following Figures 4.3-15 to 4.3-18 plot the sample means for each vertical phase of flight as a function of look ahead time (LH), where LEV denotes level flight, ASC denotes ascending and DES denotes descending.

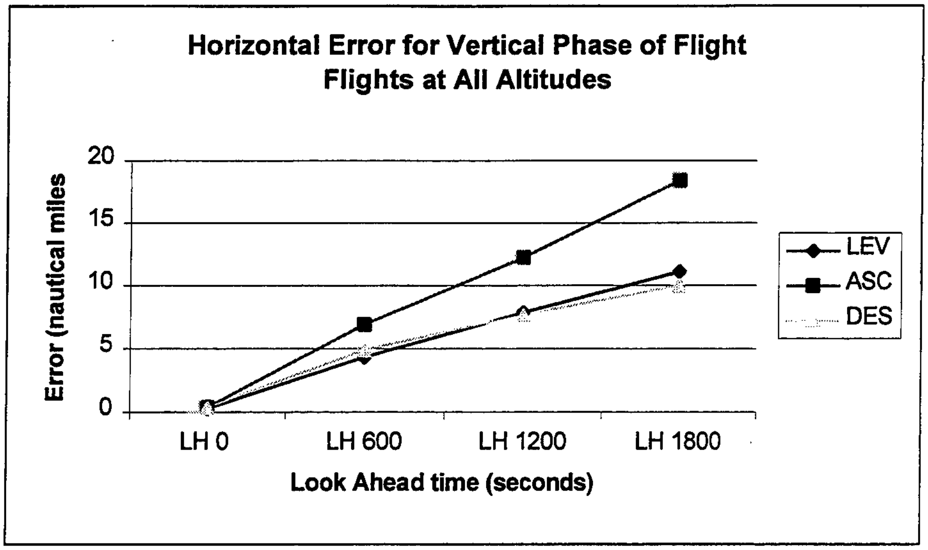

Figure 4.3-15: Sample Means for Horizontal Error per Vertical Phase of Flight and LH

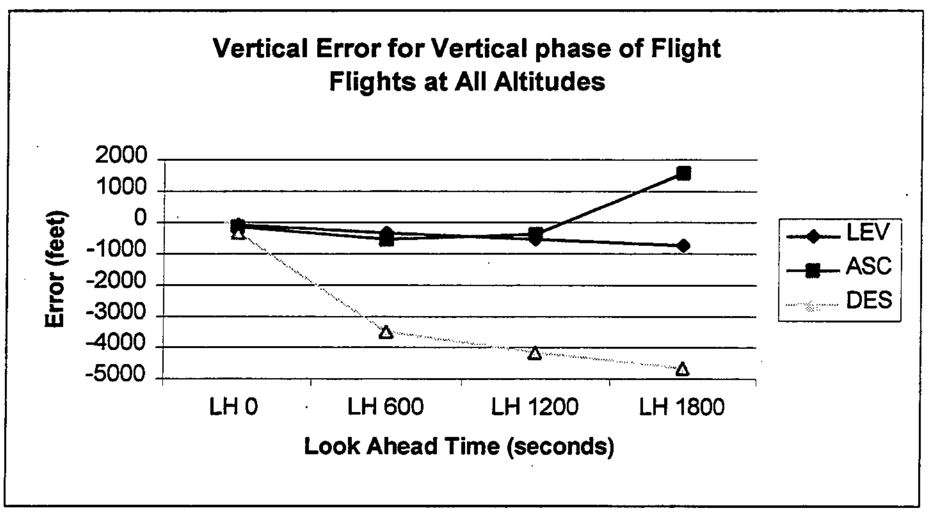

Figure 4.3-16: Sample Means for Vertical Error per Vertical Phase of Flight and LH

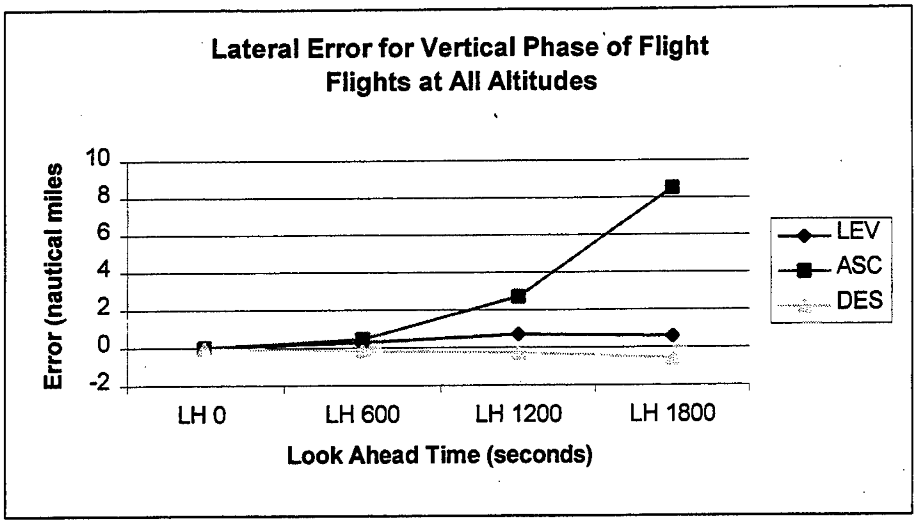

Figure 4.3-17: Sample Means for Lateral Error per Vertical Phase of Flight and LH

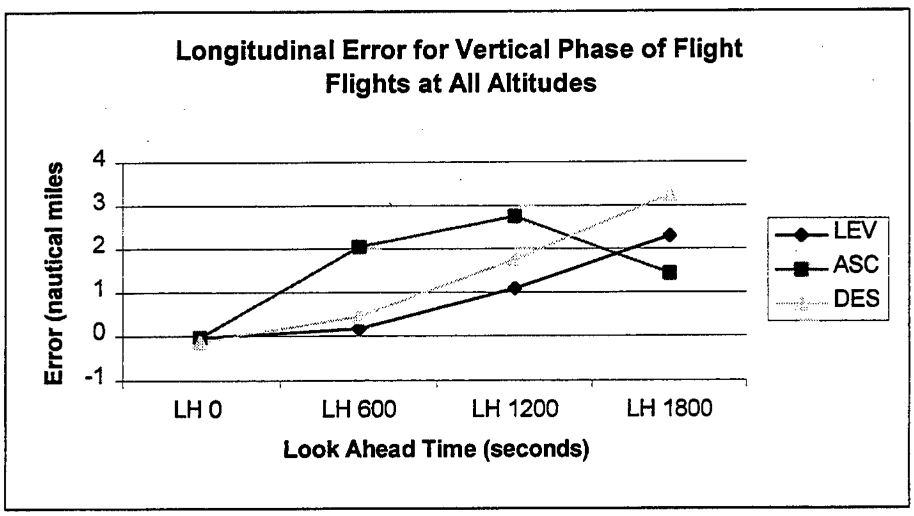

Figure 4.3-18: Sample Means for Longitudinal Error per Vertical Phase of Flight and LH

4.3.4.1 Samples at all altitudes

The results are summarized in Table 4.3-11. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-12: Statistical Results LH 0-30 minutes at All Altitudes

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-2of3	Level different from others. Ascent and descent same, larger error.
Lateral	0	Yes	No	No	Only variance significantly different.
Long.	0	Yes	Yes	Yes-2of3	Only ascent versus level not different.
Vertical	0	Yes	Yes	Yes	Descent largest error, -322 feet.
Horizontal	600	Yes	Yes	Yes-all	Level has largest error at 6.92 nautical miles (nm).
Lateral	600	Yes	Yes	Yes-2of3	Only ascent versus level not different.
Long.	600	Yes	Yes	Yes-all	Ascent has largest error, 2 nm.
Vertical	600	Yes	Yes	Yes-all	Descent has largest error, -3486 feet.
Horizontal	1200	Yes	Yes	Yes-2of3	Only level versus descent not different.
Lateral	1200	Yes	Yes	Yes-all	Ascent has largest error at 2.7 nm.
Long.	1200	No	Yes	Yes-1of3	Only descent versus level are different.
Vertical	1200	Yes	Yes	Yes-2of3	Only level versus ascent not different.
Horizontal	1800	Yes	Yes	Yes-all	Ascent has largest error, 18.4 miles. Inconclusive with ascent only 13 samples.
Lateral	1800	Yes	Yes	Yes-all	Ascent has largest error, 8.5 miles. Inconclusive with ascent only 13 samples.
Long.	1800	Yes	No	No	Only variance significantly different. Inconclusive with ascent only 13 samples.
Vertical	1800	Yes	Yes	Yes-2of3	Only level versus ascent not different. Inconclusive with ascent only 13 samples.

4.3.4.2 Samples at altitudes above 18,000 feet

The results are summarized in Table 4.3-12. The detailed histograms and statistical tables are located in Appendix A.2.

Table 4.3-13: Statistical Results LH 0-30 minutes Above 18,000 feet

Error Type	Look ahead Time	Levene Test	Welch Test	Tukey-Kramer	Observations
Horizontal	0	Yes	Yes	Yes-all	Ascent has largest error, 0.4 nm.
Lateral	0	Yes	No	No	Only variance significantly different.
Long.	0	Yes	Yes	Yes-2of3	Only level versus ascent not different.
Vertical	0	Yes	Yes	Yes-2of3	Only level versus ascent not different.
Horizontal	600	Yes	Yes	Yes-all	Ascent has largest error, 7 nm.
Lateral	600	Yes	Yes	Yes-2of3	Only level versus ascent not different.
Long.	600	Yes	Yes	Yes-2of3	Only level versus descent not different.
Vertical	600	Yes	Yes	Yes-all	Descent has largest error, -3033 feet.
Horizontal	1200	Yes	Yes	Yes-2of3	Only level versus descent not different. Ascent has larger error at 12.3 nm.
Lateral	1200	Yes	Yes	Yes-2of3	Only level versus ascent not different.
Long.	1200	Yes	No	No	Only variance significantly different.
Vertical	1200	Yes	Yes	Yes-2of3	Only level versus ascent not different.
Horizontal	1800	Yes	Yes	Yes-all	Ascent has largest error, 18.4 nm.
Lateral	1800	Yes	Yes	Yes-all	Ascent has largest error, 8.5 nm.
Long.	1800	Yes	No	No	Only variance significantly different.
Vertical	1800	Yes	Yes	Yes-all	Descent has largest error, -3745 feet.

4.3.4.3 Discussion of the effect of Vertical Phase of Flight

The vertical phase of flight does have a significant effect on the spatial errors. In particular, aircraft in ascent have samples with the largest horizontal mean error as look ahead time increases. From Figure 4.3-15, the sample means for ascending phase of flight range from 0.4 nautical miles to around 12 nautical miles from zero to 20 minutes look ahead time, respectively. There are only a few samples (i.e. 13 sample points) available at the larger look ahead times for ascending flight, making the results inconclusive for ascents at 30 minutes (1800 seconds) look ahead time.

The vertical phase of flight has a significant effect on vertical error as well. The descending phase of flight has the largest effect on the mean error, although the ascending samples have the largest standard deviation or variance at the lower look ahead times. Referring to Figure 4.3-16, the sample mean for descending phase of flight, which is a measure of the prediction bias, shows a decreasing (becomes more negative) average vertical error as look ahead time increases. Therefore, the trajectory prediction tends to overestimate the altitude. For aircraft in descent at look ahead times from five minutes to 30 minutes, the CTAS trajectory tends to predict either the altitude lagging (i.e. not descending fast enough), leaving the predicted altitude above the actual, or it may have lagged on its predicted location of the top of descent point, which has a similar effect.

The uncertainty of the prediction on the vertical dimension is measured by the standard deviation for each vertical phase of flight. Referring to Appendix A.2, the lower look ahead times between zero and five minutes show ascending phase of flight dominates with ranges of the standard deviation between 1400 and 4300 feet. For the larger look ahead times above five minutes, the descending phase of flight samples dominate with standard deviations ranging from 3500 to 4800 feet.

5. Summary

This report presents the results of an independent analysis of the accuracy of the trajectory modelers implemented in the URET and CTAS prototypes. These results are based on the completion of the first phase of a planned two phased effort. As originally envisioned, efforts during Phase 1 would develop a generic methodology to measure trajectory prediction accuracy which would be validated by applying it to CTAS and URET at their currently adapted sites. In Phase 2, the methodology would be applied to URET and CTAS systems that had been adapted to a common site and supplied with the same scenario. As such, the results from Phase 2 would have provided a common set of results based on the same site and scenario, allowing a comparison to be made of the two trajectory modelers, in support of research into the performance requirements for a common en route trajectory model. Unfortunately, due to funding cuts ACT-250 was only able to complete Phase 1. The results from this phase do provide the FAA with an independent set of scenario-based trajectory accuracy statistics for each DST, however, they cannot be used to compare the two DSTs due to the confounding site-specific factors.

A methodology was developed and CTAS and URET were measured based on one scenario each from their currently adapted sites (Fort Worth and Indianapolis, respectively). Both scenarios were approximately seven to 7.5 hours in duration and contained about 2500 flights. In the URET scenario from Indianapolis Center (ZID) used for this study, approximately 45 percent of the flights were overflights, 27 percent were departures, 25 percent were arrivals, and 3 percent were denoted "internals". For the CTAS scenario from Fort Worth Center (ZFW), the flight type mix was very different with approximately 13 percent of the flights being internals, 31 percent arrivals, 30 percent departures, and only 26 percent overflights. The differences in the scenarios for the flight type highlight the major differences between the scenarios and are one example why the Phase 1 results can only be reviewed individually.

The evaluation methodology took the point of view of the Air Traffic Controller using the DST. That is, a Controller viewing the aircraft predicted position data on the graphical user interface of the DST would ask how accurate the predictions were into the future, e.g., 5 minutes, 10 minutes, 20 minutes, and beyond. The Controller is not necessarily interested in the interior workings of the tool, e.g., how recently the tool made its currently valid predictions, but rather how accurate the prediction is now, and into the future. Built upon this conceptual point of view of the user, a sampling process was used to obtain the measurement data. At selected times the actual position of the aircraft was obtained from the HCS radar track data and was compared with the position of the aircraft predicted by the tool.

The Phase 1 study measured the spatial error between trajectory predictions versus the HCS track position reports, which were assumed to be the ground truth location of the aircraft. The spatial error consisted of horizontal and vertical errors. The horizontal error was further partitioned into two geometric components, lateral and longitudinal errors, representing the cross track and along track prediction errors. These errors were calculated for trajectories where both HCS track data and the DST trajectory overlapped in time. In a sense, a DST could incur higher accuracy with small trajectory errors if it selectively built trajectories; however, in this study both CTAS and URET made predictions on most of the available valid flights (aircraft movements that have both flight plan and verified track position information). For URET, 97 percent of the flights were analyzed and for CTAS 95 percent were analyzed.

The focus of the analysis was on the overall trajectory accuracy of each DST, not on individual errors. A statistical analysis was performed on the overall accuracy of the two modelers in their

respective Centers with their respective scenarios. This analysis was performed on approximately 17,000 URET trajectories and 32,000 CTAS trajectories. The spatial errors have been summarized with descriptive statistics in the horizontal, lateral, longitudinal, and vertical dimensions as a function of look ahead time. Inferential statistics were performed to determine whether specific factors (i.e., look ahead time, flight type, horizontal phase of flight, and vertical phase of flight) had a significant effect on these performance statistics.

For URET, the sample means for the horizontal error, as a function of look ahead time, range from 1.2 to 10.2 nautical miles for 0 to 30 minutes look ahead time. The sample standard deviations range from 1.1 to 10.9 nautical miles. For CTAS, the sample means for the horizontal error as a function of look ahead time, range from 0.3 to 10.9 nautical miles for 0 to 30 minutes look ahead time. The sample standard deviations range from 0.9 to 11.2 nautical miles. For both URET and CTAS, the average and standard deviation of the horizontal error increases as look ahead time increases. In other words, the horizontal uncertainty of the trajectory predictions analyzed in this study increased by about 10 nautical miles on average as look ahead increased from zero to 30 minutes into the future.

As previously stated, while the Phase 1 analysis cannot be used to compare the URET and CTAS trajectory modelers, the results do provide the FAA with an independent scenario based set of trajectory accuracy measurements for each DST. All of the data from this study is stored in a large set of Oracle database tables in the WJHTC TFM Laboratory. This data can be made available to other members of the FAA community who may wish to analyze other factors, or answer other questions of interest, related to the trajectory prediction accuracy of URET and CTAS upon formal request to ACT-250. In addition, a generic methodology has been developed for the performance measurement of a common trajectory model. In FY99, this methodology and the parsing tools developed in this study will be applied to the development of DSR Workload Scenarios to be used for URET CCLD accuracy testing. With the planned adaptation of URET and CTAS to a common site, tentatively scheduled to occur in 2001, and anticipated funding availability in FY01, ACT-250 hopes to resume work on the proposed Phase 2 study to further address the FAA's efforts to determine the feasibility of a common en route trajectory model.

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List of Acronyms

ACID	Aircraft Identification
ACT-250	WJHTC ATM Engineering, Research and Evaluation Branch
ARR	Arrival
ARTCC	Air Route Traffic Control Center
ASC	Ascending
ATC	Air Traffic Control
ATM	Air Traffic Management
BOD	Bottom of Descent
CAASD	Center for Advanced Aviation System Development
CCLD	Core Capability Limited Deployment
CID	Computer Identification
CLT	Central Limit Theorem
CPP	CTAS Parser Program
CTAS	Center-TRACON Automation System
DEP	Departure
DES	Descending
DST	Decision Support Tool
ENR	En Route
FAA	Federal Aviation Administration
FL	Flight Level
FFP1	Free Flight Phase 1
FP	Flight Plan
GIM	General Purpose Output Interface Module
HCS	Host Computer System
HSD	Honestly Significant Difference
IAIPT	Interagency ATM Integrated Product Team
IFR	Instrument Flight Rules
INR	Internal
JRPD	Joint Research Project Description
LEV	Level flight
LH	Look ahead time
LSD	Least Significant Difference
MTR	Monitor Test and Recording
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
nm	Nautical Mile
OVR	Overflight
RHCMP	Reverse Host Converge/Merge Process
SAS	Statistical Analysis Systems
SID	Standard Instrument Departure
ZQL	Standard Query Language
STAR	Standard Arrival Route
STD	Standard Deviation
STR	Straight
TFM	Traffic Flow Management
TJS	Trajectory Sampling
TOD	Top of Descent
TRN	Turning

URET	User Request Evaluation Tool
WJHTC	William J. Hughes Technical Center
ZFW	Fort Worth ARTCC
ZID	Indianapolis ARTCC
ZKC	Kansas City ARTCC
ZOB	Cleveland ARTCC

Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/ Center-TRACON Automation System (CTAS

APPENDIX A: Detailed Listing of Analysis Data

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APPENDIX A

A.0 Introduction to Appendix

This Appendix is a supplement to *Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/Center-TRACON Automation System (CTAS), DOT/FAA/CT-TN99/10.* Appendix A contains summary tables, charts and statistical tests selected to evaluate the URET and CTAS trajectory modeling tools. Section A.0.1 provides a summary and Section A.0.2 a description of the summary tables and the statistical charts in the Appendix A. Section A.0.3 describes the JMP charts. Section A.0.4 describes the statistical tests used in the analysis. Section A.0.5 provides a list of references for Appendix A.0.

A.0.1 Appendix Layout

The Appendix A is ordered by trajectory modeler and by the four categories analyzed in the report – look ahead time, flight type, horizontal and vertical phase of flight. Table A.0-1 shows the Appendix A layout and the charts and statistical tests for each section.

Table A.0-1: Appendix Tables and Statistical Tests by Trajectory Modeler

Section A.1 URET		Section A.2 CTAS	
A.1.1	Look Ahead Time Summary Tables Statistical Tests Box Plots and Histograms	A.2.1	Look Ahead Time Summary Tables Statistical Tests Box Plots and Histograms
A.1.2	Flight Type Summary Table Statistical Tests	A.2.2	Flight Type Summary Table Statistical Tests
A.1.3	Horizontal Phase of Flight Summary Table Statistical Tests	A.2.3	Horizontal Phase of Flight Summary Table Statistical Tests
A.1.4	Vertical Phase of Flight Summary Table Statistical Tests	A.2.4	Vertical Phase of Flight Summary Table Statistical Tests

A.0.2 Description of Summary Tables and Statistical Tests

Summary Tables

Each Appendix A section begins with a set of tables providing summary statistics for the four basic errors analyzed in the report – horizontal, lateral, longitudinal and vertical prediction error. Statistics include the sample quantity, error mean, error standard deviation, maximum and minimum values for the four errors and their absolute values as well. Figure A.0-1 shows the summary table format. This specific table is for the look ahead time category and the column headers are look ahead time in increments of 300 seconds. Other summary tables include a second set of group categories listed in the column headers. The column header for flight type has the categories OVR (over flights), ARR (arrivals), DEP (departures), and INR (internals). The column header for the horizontal phase of flight table has Turn (TRN) and Straight (STR). The table for vertical phase of flight has Level (LEV), Ascent (ASC), and Descent (DES). The left hand column of each summary table is grouped by error statistic. The order from top to bottom is horizontal error, lateral error, absolute lateral error, longitudinal error, absolute longitudinal error, vertical error, absolute vertical error, and slant range error. The order of statistics within each error group is average error, standard deviation, maximum and minimum error.

Look Ahead Time (sec)	0	300	600	900	1200	1500	1800
Sample Quantity	35928	29799	23964	18529	13836	9678	6444
Avg. Horz. Error	1.2	3.16	5.11	6.82	8.25	9.36	10.17
Stddev. Horz. Error	1.08	3.4	5.47	7.28	8.89	10.1	10.9
Max. Horz. Error	42.39	84.31	125.68	167.79	173.62	156.35	169.84
Min. Horz. Error	0	0.01	0.02	0.02	0.02	0.01	0.04
Avg. Lat. Error	-0.02	-0.1	-0.17	-0.21	-0.21	-0.24	-0.22
Stddev. Lat. Error	1.34	3.64	5.43	6.98	8.41	9.49	10.06
Max. Lat. Error	32.23	65.49	97.45	129.48	134.87	120.34	117.09
Min. Lat. Error	-16	-39.47	-61.74	-94.55	-124.94	-143.49	-155.99
Avg. Abs. Lat. Error	0.87	1.98	2.86	3.59	4.16	4.58	4.74
Stddev. Abs. Lat. Error	1.02	3.06	4.62	5.99	7.31	8.32	8.87
Max. Abs. Lat. Error	32.23	65.49	97.45	129.48	134.87	143.49	155.99
Min. Abs. Lat. Error	0	0	0	0	0	0	0
Avg. Long. Error	-0.02	0.09	0.36	0.52	0.69	0.79	0.88
Stddev. Long. Error	0.91	2.87	5.13	7.11	8.71	9.94	10.96
Max. Long. Error	11.93	25.52	91.73	94.25	96.16	97.63	98.01
Min. Long. Error	-27.53	-65.39	-79.36	-106.71	-109.33	-99.82	-78.53
Avg. Abs. Long. Error	0.61	1.88	3.31	4.6	5.73	6.64	7.42
Stddev. Abs. Long. Error	0.67	2.17	3.94	5.44	6.59	7.43	8.12
Max. Abs. Long. Error	27.53	65.39	91.73	106.71	109.33	99.82	98.01
Min. Abs. Long. Error	0	0	0	0	0	0	0
Avg. Vert. Error	49.36	-6.95	-126.58	-183.49	-200.71	-273.61	-327.15
Stddev. Vert. Error	662.94	1613.04	1960.92	2006.64	2113.7	2218.71	2298.25
Max. Vert. Error	36817	34817	28933	30746.5	37473.73	38907.87	31668.16
Min. Vert. Error	-6824.15	-12626.9	-15373.8	-16419.3	-15900	-17219.3	-15800
Avg. Abs. Vert. Error	204.12	735.26	917.9	945.74	990.05	1065.64	1099.49
Stddev. Abs. Vert. Error	632.66	1435.73	1737.43	1779.27	1878.23	1965.15	2044.49
Max. Abs. Vert. Error	36817	34817	28933	30746.5	37473.73	38907.87	31668.16
Min. Abs. Vert. Error	0	0	0	0	0	0	0
Avg. Slant Range Error	1.21	3.18	5.12	6.84	8.26	9.37	10.18
Stddev. Slant Range Error	1.09	3.39	5.46	7.27	8.88	10.09	10.89
Max. Slant Range Error	42.39	84.34	125.72	167.86	173.7	156.48	169.84
Min. Slant Range Error	0	0.01	0.02	0.03	0.02	0.01	0.04

Figure A.0-1: Example of Summary Table

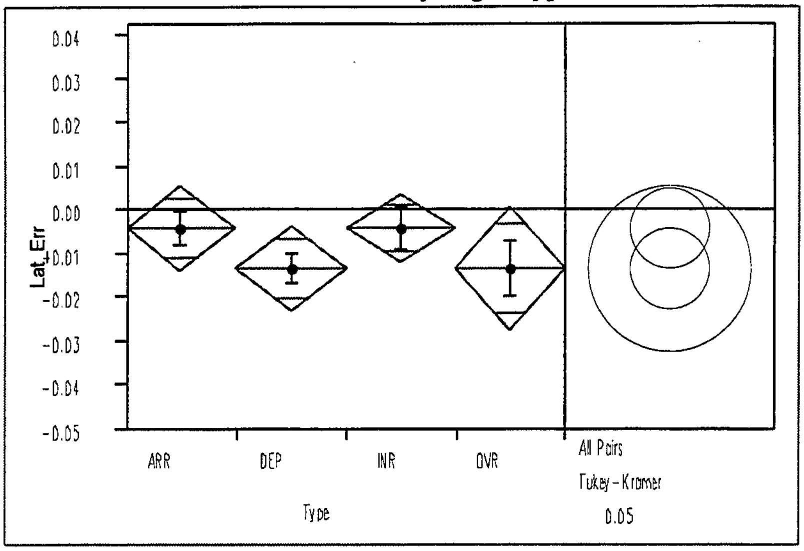
Charts and Statistical Tests

The statistical package used was SAS-JMP by Statistical Analysis Systems (SAS Institute, 1995).

The common graphical approach in each section was to plot the mean error by each factor. Figure A.0-2 on the following page shows a typical plot for the flight type category. The measured error in this plot is lateral error and the categories along the horizontal axis are Arrivals, Departures, Internals and Overflights. A detailed description of the chart components is provided in Section A.0.3.

Below the plot in Figure A.0-2 is numerical information provided by the JMP package including the mean and standard deviation of the error and the three statistical tests selected to analyze the data. The three tests are the Tukey-Kramer HSD (i.e. Honestly Significant Difference) Test, the Levene Test, and the Welch Test. Additional information on each test is provided in Section A.0.3.

Lateral Error By Flight Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	8185	0.001265	0.395929	0.00438
DEP	7976	-0.00456	0.346604	0.00388
INR	12651	0.004980	0.555031	0.00493
OVR	3747	-0.00662	0.393963	0.00644

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.000000	0.003715	0.009536	0.011603
ARR	-0.00372	0.000000	0.005821	0.007887
DEP	-0.00954	-0.00582	0.000000	0.002067
OVR	-0.0116	-0.00789	-0.00207	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56916

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-0.01468	-0.01284	-0.00715	-0.01011
ARR	-0.01284	-0.01825	-0.01254	-0.01514
DEP	-0.00715	-0.01254	-0.01848	-0.02105
OVR	-0.01011	-0.01514	-0.02105	-0.02697

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	8185	0.3959291	0.1264577	0.1264098
DEP	7976	0.3466043	0.1027734	0.1024725
INR	12651	0.5550314	0.1533673	0.1527684
OVR	3747	0.3939632	0.0873013	0.0864671

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.1363	3	32555	0.0243
Brown-Forsythe	33.9400	3	32555	<.0001
Levene	34.0393	3	32555	<.0001
Bartlett	856.3893	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.1128	3	13778	0.3424

Figure A.0-2: Example of JMP Chart for Group Comparison of the Means

A.0.3 Description of JMP Charts

Graphical analysis of the mean error for each category (i.e. look ahead time, flight type, horizontal phase of flight, and vertical phase of flight) display plots that included quantile box plots, means diamonds, error bars and comparison circles, and histograms with outlier box plots.

Quantile Box Plot

The quantile box plot is a "fit y by x" plot used in the analysis of horizontal, lateral, longitudinal and vertical error by look ahead time. The selected JMP plot options include display of connected means dots and quantile boxes. Figure A.0-3 is a typical plot showing horizontal error at each look ahead time. Figure A.0-4 provides a detailed description of the plot components.

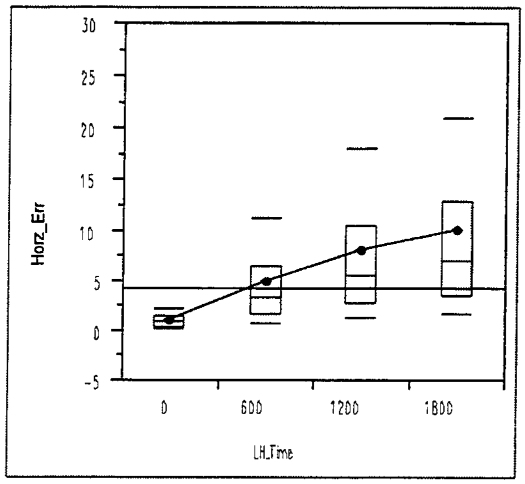


Figure A.0-3: Connected Means and Quantile Box Plot

Figure A.0-4 is a portion of the above plot and identifies the plot components. A horizontal line representing the grand mean for all observations, the means connected by dots, the median and various quantiles for each group are shown.

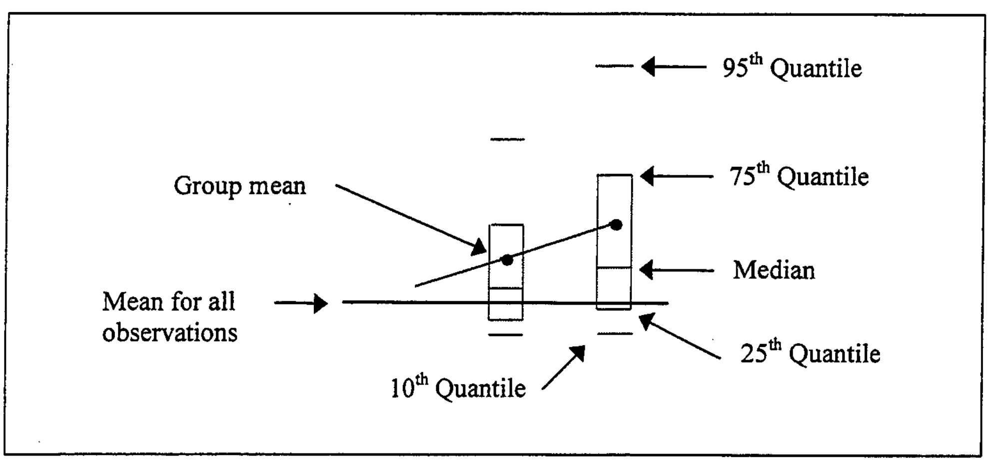


Figure A.0-4: Components of JMP Means and Quantile Box Plot

Means Diamonds and T-K Comparison Circles

Figure A.0-5 is a typical JMP plot option used to graphically present summary statistics and the Tukey-Kramer (T-K) Test. The left portion of the chart shows means diamonds, means dots with error bars. The right portion shows the T-K means comparison circles. A detailed description of the plot components is provided below.

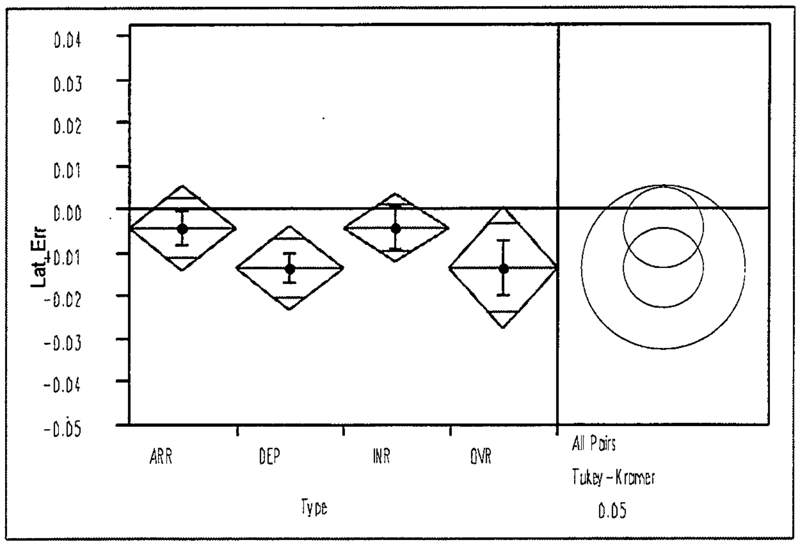


Figure A.0-5: Means Diamonds and Tukey-Kramer Significance Test

Means Diamonds, Means Dots and Error Bars

Figure A.0-6 identifies the components of the JMP mean diamond plot option. Mean diamonds are a schematic of the mean and standard error of the mean for each sample group. The green colored horizontal line across each diamond represents the group mean. The height of each diamond represents the 95% confidence interval for the group. The diamond's width for this study is equivalent for all groups for display purposes, however JMP defaults the diamond's width to be proportional to the group sample size. The blue colored dots represent the group means and the blue colored vertical bars represent one standard error ($STD / \sqrt{n}$) above and below each group mean. The horizontal line crossing several diamonds represents the mean for all observations.

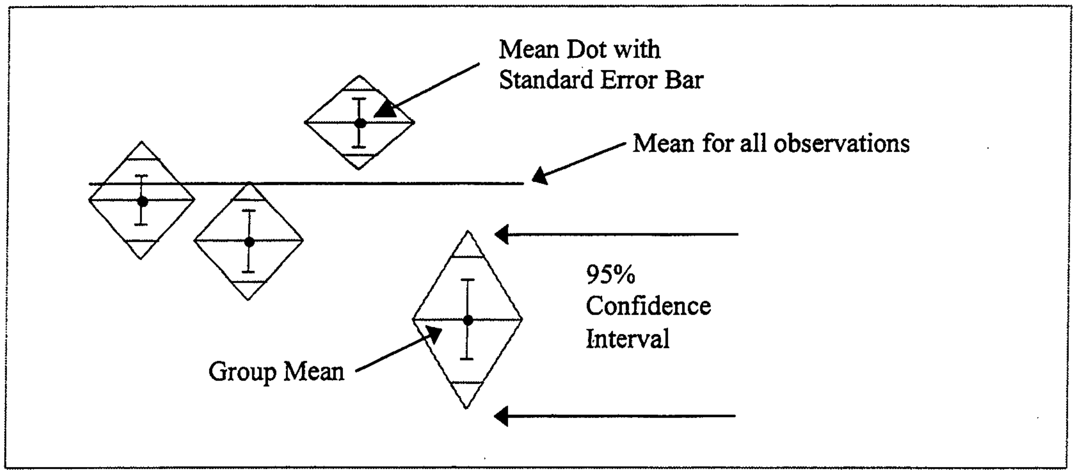


Figure A.0-6: Components of Means Diamonds Plot Option

Means Comparison Circles

JMP provides comparison circles as a graphical representation for the Tukey-Kramer Test. The comparison circle radius is calculated as follows.

$$\text{Radius} = \hat{u}_i + |\,q^*\,|\,\hat{\sigma}\sqrt{n_i^{-1}} \qquad \textbf{Equation A.0-1}$$

where,

$\hat{u}_i$ is the group mean

q^* is a test value similar to the Student t provided by JMP

$\hat{\sigma}$ is the group standard deviation

n_i is the group sample size

By the Pythagorean theorem, a pair of means can be inferred to be significantly different if either circles do not overlap, or if they do overlap, the outer angle formed by the tangent lines through the point at which the circles intersect is greater than 90 degrees. Figure A.0-7 displays this test geometry (SAS Institute, 1995).

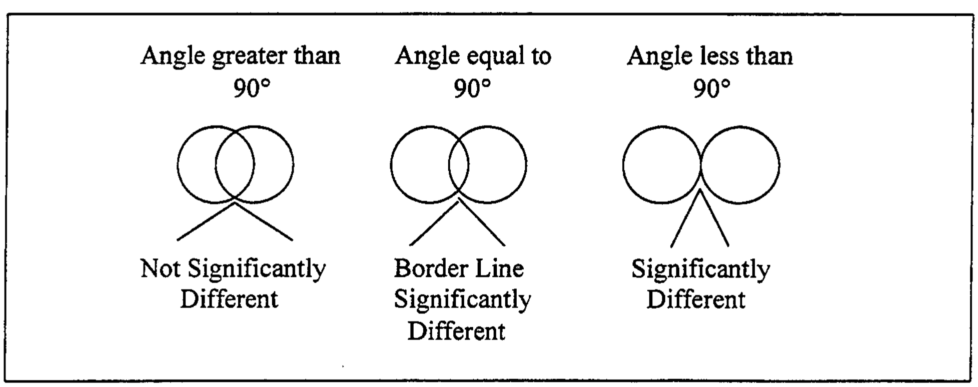


Figure A.0-7: Geometry for JMP representation of Tukey-Kramer Comparison Circles

Figure A.0-8 displays the connection between the mean diamonds and the comparison circles. Each diamond is represented by a circle. Each circle is vertically centered at the group mean and drawn with a radius as described above. An analysis of the circles in this example indicates that none of the factors are significantly different. This is illustrated by overlapping circles in Figure A0-8.

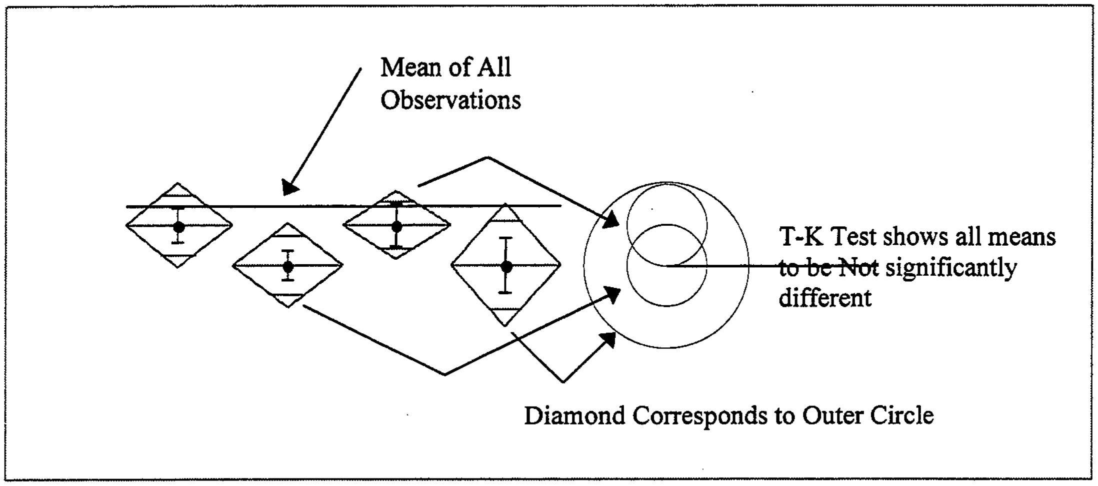


Figure A.0-8: Connection between Means Diamonds and Comparison Circles

Histograms and Outlier Box Plots

Figure A.0-9 shows a combination histogram and outlier box plot option provided by JMP. This example plot is specifically for lateral error at look ahead time zero for flights at all altitudes. Histograms were plotted for each error for each look ahead time category only.

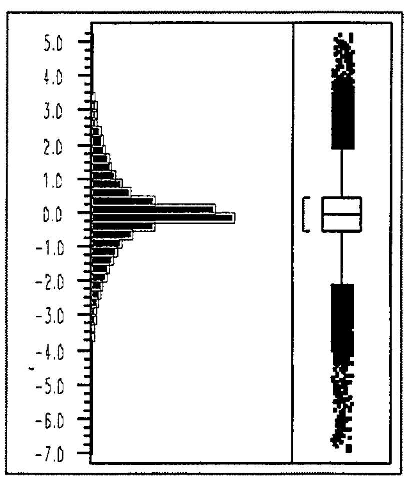


Figure A.0-9: Histogram and Outlier Plot

Additional description of the histogram is not required beyond indicating that the error variable for the data set is continuous and that the axis is therefore broken into intervals. The height of each bar indicates the relative frequency for the interval. Figure A.0-10 defines the components for the outlier box plot.

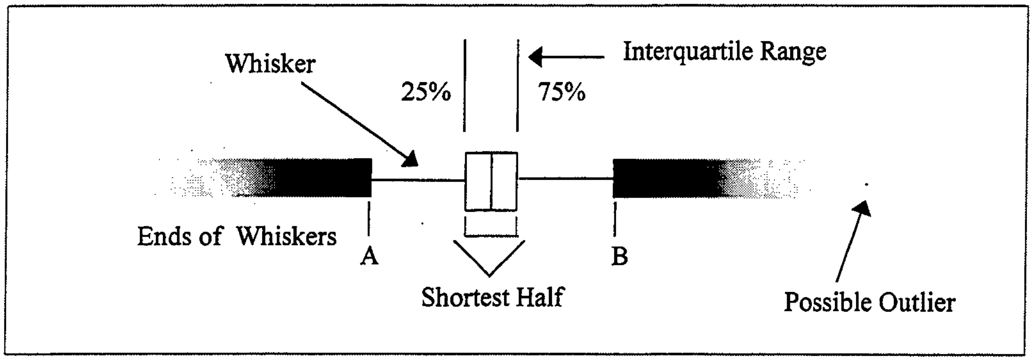


Figure A.0-10: Outlier Box Plot

Definitions for the components in the above Figure A.0-10 are as follows. The center box encompasses 50 percent of the sample data – the left and right ends demark the 25 percent and 75 percent quartile. The centerline of the box represents the median sample value. The ends of the whiskers (A and B) are the outer-most data points from their respective quartiles that fall within the distance computed as 1.5 times the interquartile range. The bracket along the edge of the box identifies the shortest half or the most dense 50 percent of the observations. The outlier is a possible extreme value.

A.0.4 Description of Statistical Tests

The statistical tests selected from the JMP package to evaluate the error data were the Tukey-Kramer Test, the Levene Test, and the Welch Test. A brief description of each follows.

Tukey-Kramer Test

The Tukey-Kramer method is used to compare means having unequal sample sizes. The approximate simultaneous confidence intervals for all pairwise differences are calculated as

$$\text{Confidence Interval} = u_i - u_j \pm | q^* | \hat{\sigma} \sqrt{n_i^{-1} + n_j^{-1}} \qquad \textbf{Equation A.0-2}$$

where,

q^* is the critical value such that the coverage probability equals $1-\alpha$ percent

The q^* is the quantile used to scale the LSD's and has a computational role comparable to the t in the Student's Distribution.

Figure A.0-11 shows the JMP format for the Tukey-Kramer Test. Positive values in any intersection indicates that pairs of means are significantly different. The α significance level and q^* are provided. The tables values represent the actual absolute difference in the means minus the LSD, which is the

difference that would be significant. The more significantly different means are located in the northeast and southwest corners of the table (SAS Institute, 1995).

Alpha=	0.05			
	Comparisons for all pairs using Tukey-Kramer HSD			
	q* = 2.56916			
Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-0.02743	-0.00266	0.010011	0.017529
ARR	-0.00266	-0.0341	-0.02141	-0.01321
DEP	0.010011	-0.02141	-0.03455	-0.02631
OVR	0.017529	-0.01321	-0.02631	-0.0504

Positive values show pairs of means that are significantly different.

Figure A.0-11: Typical JMP Table for Tukey-Kramer HSD Test

Levene Test

The Levene method is a nonparametric ANOVA technique applied when the data is non-normally distributed and have unequal variances. This method is carried out on the absolute difference between observations and the group mean defined as Z_{ij} rather than each observation, y_{ij}.

$$Z_{ij} = | y_{ij} - \bar{y}_{.j} | \quad i = 1,2,...,n_j; \quad j = 1,2,...,g$$ **Equation A.0-3**

where,

n is the number of observations within a group
g is the number of group means in the comparison

The test statistic is the F-ratio with (g-1) and (n-g) degrees of freedom. The JMP test result is given as the p-value. Figure A.0-12 shows the typical results format (Neter, 1996).

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.5146	3	32555	0.6722
Brown-Forsythe	3.8946	3	32555	0.0086
Levene	**5.3436**	**3**	**32555**	**0.0011**
Bartlett	174.2707	3	?	<.0001

Figure A.0-12: Typical JMP Table for Levene and Additional Tests

Welch Test

The Welch Test is another ANOVA test for the equality of group means allowing that the group variances and sample sizes may be unequal. Figure A.0-13 shows the JMP format for the Welch Test.

Welch Anova testing Means Equal, allowing Std's Not Equal			
F Ratio	DF Num	DF Den	Prob>F
6.4294	3	13550	0.0002

Figure A.0-13: Typical JMP Table for Welch Test

The typical statistical F-ratio used to test the hypothesis that the means are equal is calculated for the Welch Test as follows (Kelton and Law, 1991),

$$F = \frac{\left[\dfrac{\sum_i w_i\left(\bar{y}_{i.} - \tilde{y}_{..}\right)^2}{k-1}\right]}{\left\{1 + \dfrac{2(k-2)}{k^2-1}\left[\sum_i \dfrac{\left(1-\dfrac{w_i}{u}\right)^2}{n_i - 1}\right]\right\}} \qquad \textbf{Equation A.0-4}$$

where,

$$w_i = \frac{n_i}{s_i^2}$$

$$u = \sum_i w_i$$

$$\tilde{y}_{..} = \sum \frac{w_i \bar{y}_{i.}}{u}$$

and,

k is the number of sample groups

n_i is the sample count of the ith group

s_i^2 is the response sample variance for the ith group

$\bar{y}_{i.}$ is the mean response for the ith group

The degrees of freedom for the test statistic numerator and denominator are calculated as follows,

$$\text{DF Num} = k - 1 \qquad \textbf{Equation A.0-5}$$

$$\text{DF Den} = \frac{1}{\left(\frac{3}{k^2-1}\right)\left[\sum_i \frac{\left(1-\frac{w_i}{u}\right)^2}{n_i-1}\right]}$$ **Equation A.0-6**

A.0.5 References for Appendix Introduction

Devore, J., *Probability and Statistics for Engineering and the Sciences,* Duxbury Press, 1995.

Kelton, D., Law, A., *Simulation Modeling And Analysis*, *Second Edition*, McGraw-Hill, Incorporated, New York, 1991.

Neter, John, et Al., *Applied Linear Regression Models, Third Edition,* Irwin, 1996.

SAS Institute, *JMP Statistics and Graphics Guide, Version 3, JMP Software Package*, 1995.

A.1 URET

A.1.1 Look Ahead Time

A.1.1.1 Summary Tables

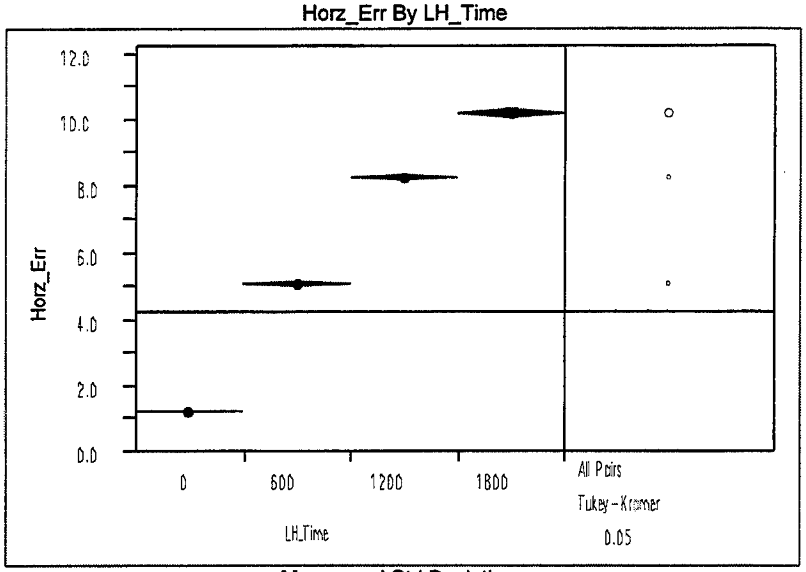
Look Ahead Time (sec)	0	300	600	900	1200	1500	1800
Sample Quantity	35928	29799	23964	18529	13836	9678	6444
Avg. Horz. Error	1.2	3.16	5.11	6.82	8.25	9.36	10.17
Stddev. Horz. Error	1.08	3.4	5.47	7.28	8.89	10.1	10.9
Max. Horz. Error	42.39	84.31	125.68	167.79	173.62	156.35	169.84
Min. Horz. Error	0	0.01	0.02	0.02	0.02	0.01	0.04
Avg. Lat. Error	-0.02	-0.1	-0.17	-0.21	-0.21	-0.24	-0.22
Stddev. Lat. Error	1.34	3.64	5.43	6.98	8.41	9.49	10.06
Max. Lat. Error	32.23	65.49	97.45	129.48	134.87	120.34	117.09
Min. Lat. Error	-16	-39.47	-61.74	-94.55	-124.94	-143.49	-155.99
Avg. Abs. Lat. Error	0.87	1.98	2.86	3.59	4.16	4.58	4.74
Stddev. Abs. Lat. Error	1.02	3.06	4.62	5.99	7.31	8.32	8.87
Max. Abs. Lat. Error	32.23	65.49	97.45	129.48	134.87	143.49	155.99
Min. Abs. Lat. Error	0	0	0	0	0	0	0
Avg. Long. Error	-0.02	0.09	0.36	0.52	0.69	0.79	0.88
Stddev. Long. Error	0.91	2.87	5.13	7.11	8.71	9.94	10.96
Max. Long. Error	11.93	25.52	91.73	94.25	96.16	97.63	98.01
Min. Long. Error	-27.53	-65.39	-79.36	-106.71	-109.33	-99.82	-78.53
Avg. Abs. Long. Error	0.61	1.88	3.31	4.6	5.73	6.64	7.42
Stddev. Abs. Long. Error	0.67	2.17	3.94	5.44	6.59	7.43	8.12
Max. Abs. Long. Error	27.53	65.39	91.73	106.71	109.33	99.82	98.01
Min. Abs. Long. Error	0	0	0	0	0	0	0
Avg. Vert. Error	49.36	-6.95	-126.58	-183.49	-200.71	-273.61	-327.15
Stddev. Vert. Error	662.94	1613.04	1960.92	2006.64	2113.7	2218.71	2298.25
Max. Vert. Error	36817	34817	28933	30746.5	37473.73	38907.87	31668.16
Min. Vert. Error	-6824.15	-12626.9	-15373.8	-16419.3	-15900	-17219.3	-15800
Avg. Abs. Vert. Error	204.12	735.26	917.9	945.74	990.05	1065.64	1099.49
Stddev. Abs. Vert. Error	632.66	1435.73	1737.43	1779.27	1878.23	1965.15	2044.49
Max. Abs. Vert. Error	36817	34817	28933	30746.5	37473.73	38907.87	31668.16
Min. Abs. Vert. Error	0	0	0	0	0	0	0
Avg. Slant Range Error	1.21	3.18	5.12	6.84	8.26	9.37	10.18
Stddev. Slant Range Error	1.09	3.39	5.46	7.27	8.88	10.09	10.89
Max. Slant Range Error	42.39	84.34	125.72	167.86	173.7	156.48	169.84
Min. Slant Range Error	0	0.01	0.02	0.03	0.02	0.01	0.04

Figure A.1- 1 Descriptive Statistics for Look Ahead Times 0 to 1800 Seconds from All Samples

Look Ahead Time (sec)	0	300	600	900	1200	1500	1800
Sample Quantity	26148	22500	18210	13972	10374	7307	4891
Avg. Horz. Error	1.14	3.18	5.22	6.99	8.45	9.65	10.62
Stddev. Horz. Error	0.94	3.54	5.7	7.65	9.32	10.63	11.55
Max. Horz. Error	42.39	84.31	125.68	167.79	173.62	156.35	169.84
Min. Horz. Error	0	0.01	0.02	0.03	0.02	0.01	0.04
Avg. Lat. Error	-0.02	-0.12	-0.23	-0.28	-0.27	-0.38	-0.44
Stddev. Lat. Error	1.2	3.8	5.82	7.58	9.18	10.25	10.75
Max. Lat. Error	32.23	65.49	97.45	129.48	134.87	120.34	117.09
Min. Lat. Error	-6.04	-39.47	-61.74	-94.55	-124.94	-143.49	-155.99
Avg. Abs. Lat. Error	0.8	2.02	3.06	3.91	4.59	4.98	5.08
Stddev. Abs. Lat. Error	0.89	3.22	4.95	6.5	7.95	8.96	9.48
Max. Abs. Lat. Error	32.23	65.49	97.45	129.48	134.87	143.49	155.99
Min. Abs. Lat. Error	0	0	0	0	0	0	0
Avg. Long. Error	-0.02	0.13	0.4	0.54	0.8	0.87	0.78
Stddev. Long. Error	0.86	2.86	5.07	7.03	8.56	10.01	11.39
Max. Long. Error	11.93	25.52	91.73	94.25	96.16	97.63	98.01
Min. Long. Error	-27.53	-65.39	-79.36	-106.71	-109.33	-99.82	-78.53
Avg. Abs. Long. Error	0.59	1.85	3.25	4.49	5.57	6.62	7.62
Stddev. Abs. Long. Error	0.63	2.19	3.91	5.44	6.54	7.55	8.51
Max. Abs. Long. Error	27.53	65.39	91.73	106.71	109.33	99.82	98.01
Min. Abs. Long. Error	0	0	0	0	0	0	0
Avg. Vert. Error	38.78	59.57	13.09	-42.69	-103.07	-169.1	-180.17
Stddev. Vert. Error	591.85	1454.4	1819.69	1852.29	1926.2	2029.34	2142.77
Max. Vert. Error	36817	34817	28933	30746.5	37473.73	38907.87	31668.16
Min. Vert. Error	-2800	-10304.6	-10552	-10700	-10485.7	-9483.61	-10550
Avg. Abs. Vert. Error	136.88	596.82	771.9	779.14	776.69	839.48	893.45
Stddev. Abs. Vert. Error	577.11	1327.64	1647.91	1680.98	1765.66	1855.27	1955.9
Max. Abs. Vert. Error	36817	34817	28933	30746.5	37473.73	38907.87	31668.16
Min. Abs. Vert. Error	0	0	0	0	0	0	0
Avg. Slant Range Error	1.14	3.2	5.23	7	8.46	9.66	10.63
Stddev. Slant Range Error	0.94	3.54	5.7	7.65	9.31	10.63	11.54
Max. Slant Range Error	42.39	84.34	125.72	167.86	173.7	156.48	169.84
Min. Slant Range Error	0	0.01	0.02	0.03	0.02	0.01	0.04

Figure A.1- 2 Descriptive Statistics for Look Ahead Times 0 to 1800 Seconds from Samples at Altitudes Above 18,000 Feet

A.1.1.2 Statistical Tests



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	35928	1.2048	1.0839	0.00572
600	23964	5.1080	5.4667	0.03531
1200	13836	8.2473	8.8872	0.07555
1800	6444	10.1669	10.8984	0.13576

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.00000	1.91965	5.05891	8.96211
1200	-1.91965	0.00000	3.13926	7.04246
600	-5.05891	-3.13926	0.00000	3.90320
0	-8.96211	-7.04246	-3.90320	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.25856	1.69830	4.85296	8.76356
1200	1.69830	-0.17645	2.98256	6.89562
600	4.85296	2.98256	-0.13408	3.78080
0	8.76356	6.89562	3.78080	-0.10950

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

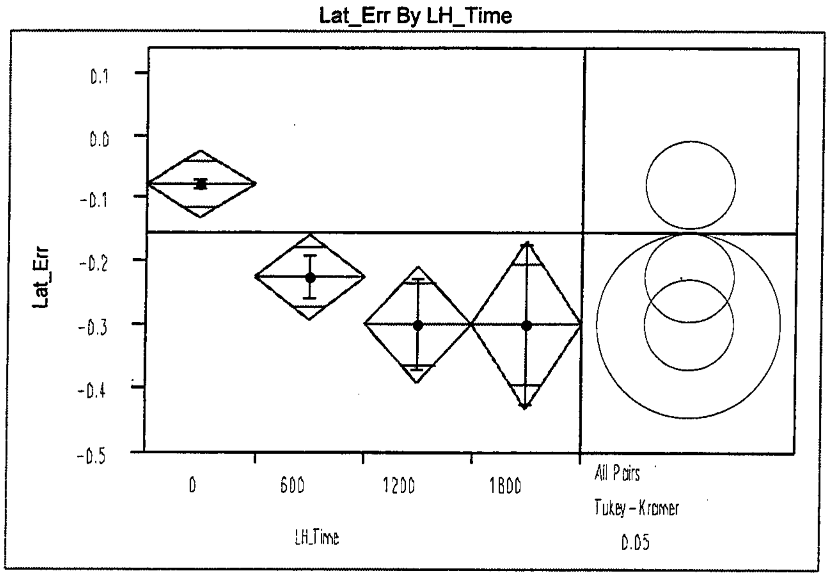
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	35928	1.08390	0.713831	0.685369
600	23964	5.46669	3.659114	3.360835
1200	13836	8.88717	5.819963	5.386845
1800	6444	10.89841	7.014038	6.490122

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	438.8907	3	80168	<.0001
Brown-Forsythe	4945.2758	3	80168	0.0000
Levene	7382.1189	3	80168	0.0000
Bartlett	33662.339	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8172.2643	3	18809	0.0000

Figure A.1- 3 Statistical Tests for Horizontal Error and Look Ahead Time for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	35928	-0.02289	1.3424	0.00708
600	23964	-0.17089	5.4328	0.03509
1200	13836	-0.21287	8.4066	0.07147
1800	6444	-0.22177	10.0570	0.12528

Means Comparisons

Dif=Mean[i]-Mean[j]	0	600	1200	1800
0	0.000000	0.147991	0.189972	0.198874
600	-0.14799	0.000000	0.041980	0.050883
1200	-0.18997	-0.04198	0.000000	0.008903
1800	-0.19887	-0.05088	-0.0089	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	.0	600	1200	1800
0	-0.10491	0.030718	0.049287	0.008655
600	0.030718	-0.12845	-0.10815	-0.14643
1200	0.049287	-0.10815	-0.16905	-0.20316
1800	0.008655	-0.14643	-0.20316	-0.24771

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	35928	1.34238	0.871379	0.871062
600	23964	5.43278	2.881018	2.864207
1200	13836	8.40656	4.184118	4.157163
1800	6444	10.05703	4.775601	4.743031

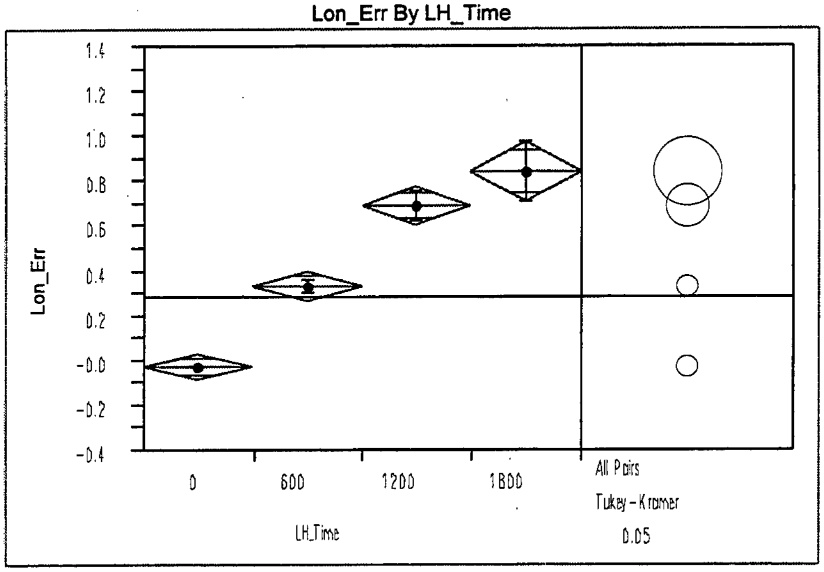
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	447.7444	3	80168	<.0001
Brown-Forsythe	2485.9252	3	80168	0.0000
Levene	2539.9707	3	80168	0.0000
Bartlett	27206.524	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.6634	3	18950	<.0001

Figure A.1- 4 Statistical Tests for Lateral Error and Look Ahead Time for Samples at All Altitudes

Lon_Err By LH_Time



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	35928	-0.01595	0.9075	0.00479
600	23964	0.361484	5.1286	0.03313
1200	13836	0.694580	8.7067	0.07402
1800	6444	0.875566	10.9635	0.13657

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.000000	0.180986	0.514082	0.891517
1200	-0.18099	0.000000	0.333096	0.710531
600	-0.51408	-0.3331	0.000000	0.377436
0	-0.89152	-0.71053	-0.37744	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.25189	-0.03465	0.313445	0.698090
1200	-0.03465	-0.1719	0.180432	0.567474
600	0.313445	0.180432	-0.13062	0.258185
0	0.698090	0.567474	0.258185	-0.10668

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

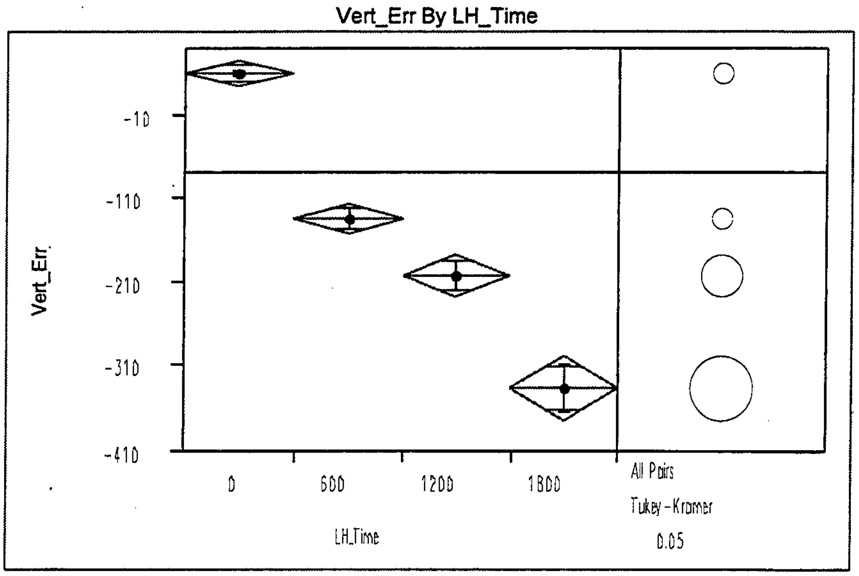
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	35928	0.90754	0.608203	0.608152
600	23964	5.12860	3.300234	3.299056
1200	13836	8.70666	5.696847	5.696779
1800	6444	10.96346	7.376215	7.376185

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1089.3936	3	80168	0.0000
Brown-Forsythe	8142.8187	3	80168	0.0000
Levene	8145.8936	3	80168	0.0000
Bartlett	37702.337	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
86.1528	3	18755	<.0001

Figure A.1- 5 Statistical Tests for Longitudinal Error and Look Ahead Time for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	35928	49.356	662.94	3.497
600	23964	-126.578	1960.92	12.667
1200	13836	-200.706	2113.70	17.970
1800	6444	-327.149	2298.25	28.630

Means Comparisons

Dif=Mean[i]-Mean[j]	0	600	1200	1800
0	0.000	175.935	250.062	376.506
600	-175.935	0.000	74.128	200.571
1200	-250.062	-74.128	0.000	126.443
1800	-376.506	-200.571	-126.443	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	0	600	1200	1800
0	-30.560	141.773	209.081	321.094
600	141.773	-37.419	30.394	143.095
1200	209.081	30.394	-49.245	64.669
1800	321.094	143.095	64.669	-72.159

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

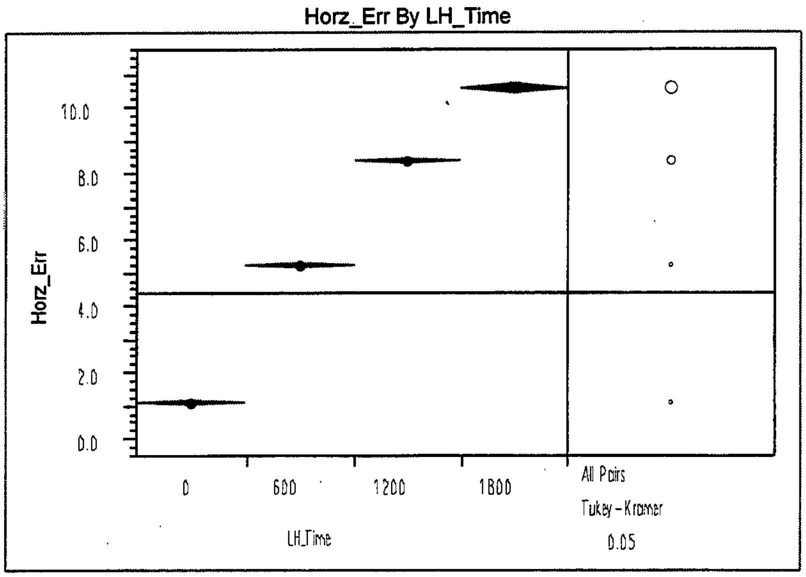
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	35928	662.937	228.883	204.125
600	23964	1960.920	980.693	917.897
1200	13836	2113.700	1091.512	990.048
1800	6444	2298.255	1262.250	1099.493

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	346.4660	3	80168	<.0001
Brown-Forsythe	1926.9792	3	80168	0.0000
Levene	2460.3926	3	80168	0.0000
Bartlett	13539.252	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
166.8785	3	19585	<.0001

Figure A.1- 6 Statistical Tests for Vertical Error and Look Ahead Time for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	26148	1.1369	0.9427	0.00583
600	18210	5.2202	5.7019	0.04225
1200	10374	8.4471	9.3181	0.09149
1800	4891	10.6181	11.5491	0.16514

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.00000	2.17100	5.39794	9.48126
1200	-2.17100	0.00000	3.22694	7.31026
600	-5.39794	-3.22694	0.00000	4.08332
0	-9.48126	-7.31026	-4.08332	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56910

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.31329	1.90228	5.14843	9.23990
1200	1.90228	-0.21512	3.03637	7.13049
600	5.14843	3.03637	-0.16236	3.93378
0	9.23990	7.13049	3.93378	-0.13550

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	26148	0.94270	0.651186	0.630549
600	18210	5.70192	3.823976	3.488516
1200	10374	9.31807	6.029985	5.557946
1800	4891	11.54910	7.371841	6.820868

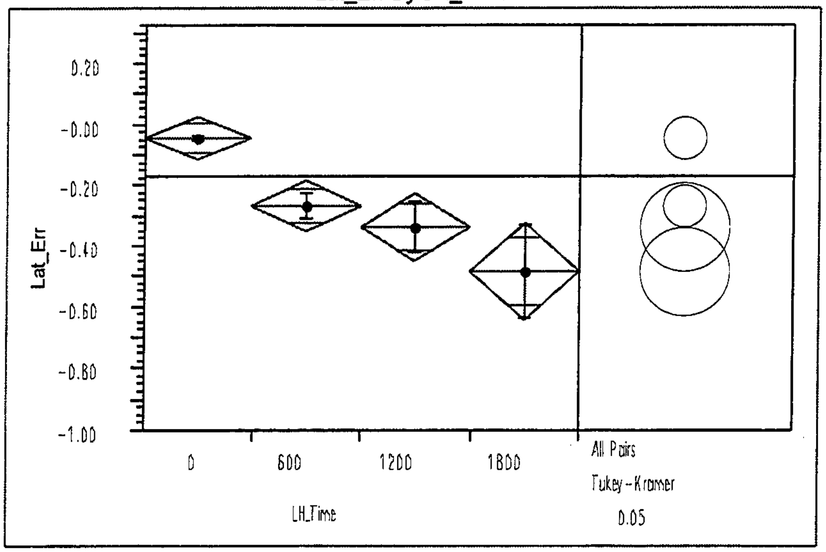
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	320.4503	3	59619	<.0001
Brown-Forsythe	3634.9075	3	59619	0.0000
Levene	5489.3036	3	59619	0.0000
Bartlett	27901.034	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6203.3622	3	14182	0.0000

Figure A.1- 7 Statistical Tests for Horizontal Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Lat_Err By LH_Time



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	26148	-0.02491	1.1993	0.00742
600	18210	-0.23282	5.8169	0.04311
1200	10374	-0.26522	9.1795	0.09012
1800	4891	-0.44387	10.7500	0.15371

Means Comparisons

Dif=Mean[i]-Mean[j]	0	600	1200	1800
0	0.000000	0.207907	0.240304	0.418956
600	-0.20791	0.000000	0.032397	0.211049
1200	-0.2403	-0.0324	0.000000	0.178652
1800	-0.41896	-0.21105	-0.17865	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56910

Abs(Dif)-LSD	0	600	1200	1800
0	-0.13312	0.060990	0.063682	0.181820
600	0.060990	-0.15952	-0.15484	-0.0341
1200	0.063682	-0.15484	-0.21135	-0.08537
1800	0.181820	-0.0341	-0.08537	-0.30781

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	26148	1.19928	0.803931	0.803539
600	18210	5.81685	3.088452	3.058630
1200	10374	9.17947	4.634173	4.594108
1800	4891	10.75002	5.179103	5.080457

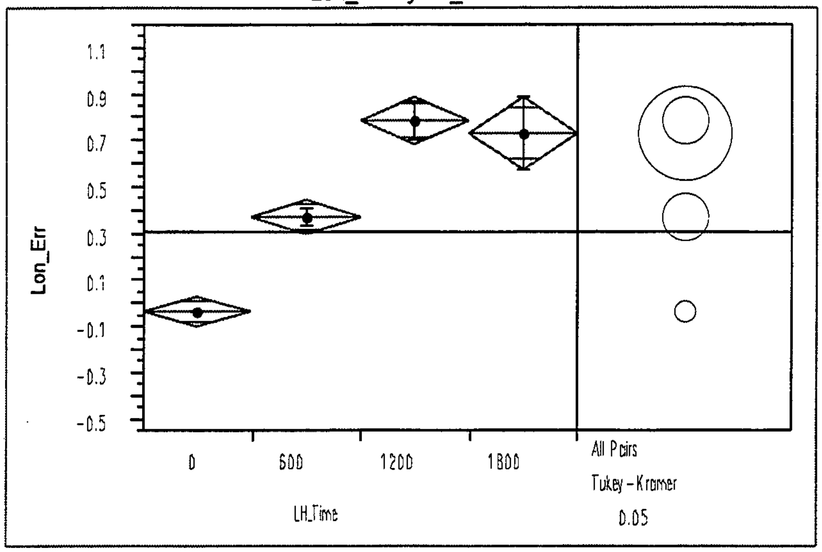
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	356.9652	3	59619	<.0001
Brown-Forsythe	2021.3661	3	59619	0.0000
Levene	2102.8972	3	59619	0.0000
Bartlett	23098.169	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
12.1520	3	14260	<.0001

Figure A.1- 8 Statistical Tests for Lateral Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Lon_Err By LH_Time



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	26148	-0.02453	0.8612	0.00533
600	18210	0.399772	5.0709	0.03758
1200	10374	0.798268	8.5567	0.08401
1800	4891	0.776635	11.3924	0.16290

Means Comparisons

Dif=Mean[i]-Mean[j]	1200	1800	600	0
1200	0.000000	0.021634	0.398496	0.822802
1800	-0.02163	0.000000	0.376863	0.801168
600	-0.3985	-0.37686	0.000000	0.424306
0	-0.8228	-0.80117	-0.42431	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56910

Abs(Dif)-LSD	1200	1800	600	0
1200	-0.20041	-0.22872	0.220953	0.655324
1800	-0.22872	-0.29187	0.144411	0.576311
600	0.220953	0.144411	-0.15126	0.284995
0	0.655324	0.576311	0.284995	-0.12623

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

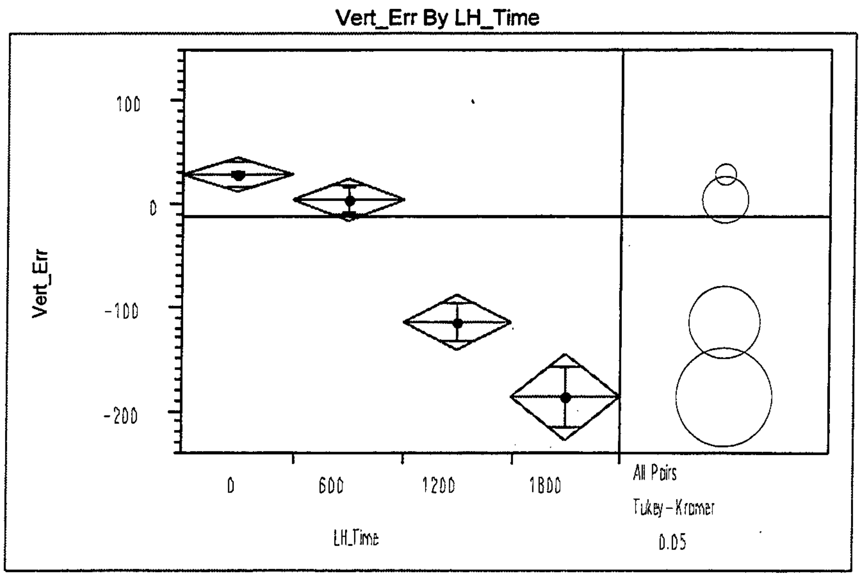
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	26148	0.86125	0.591115	0.591057
600	18210	5.07091	3.245947	3.242524
1200	10374	8.55670	5.551472	5.547547
1800	4891	11.39239	7.592835	7.592169

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	753.7629	3	59619	0.0000
Brown-Forsythe	5913.6135	3	59619	0.0000
Levene	5930.1703	3	59619	0.0000
Bartlett	28718.836	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
80.6834	3	14183	<.0001

Figure A.1- 9 Statistical Tests for Longitudinal Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	26148	38.780	591.85	3.660
600	18210	13.094	1819.69	13.485
1200	10374	-103.070	1926.20	18.912
1800	4891	-180.173	2142.77	30.639

Means Comparisons

Dif=Mean[i]-Mean[j]	0	600	1200	1800
0	0.000	25.686	141.850	218.952
600	-25.686	0.000	116.164	193.266
1200	-141.850	-116.164	0.000	77.103
1800	-218.952	-193.266	-77.103	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56910

Abs(Dif)-LSD	0	600	1200	1800
0	-33.229	-10.986	97.764	159.762
600	-10.986	-39.818	69.428	132.077
1200	97.764	69.428	-52.754	11.202
1800	159.762	132.077	11.202	-76.830

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	26148	591.852	160.7907	136.8790
600	18210	1819.695	780.0067	771.9043
1200	10374	1926.200	835.6573	776.6929
1800	4891	2142.772	998.2717	893.4473

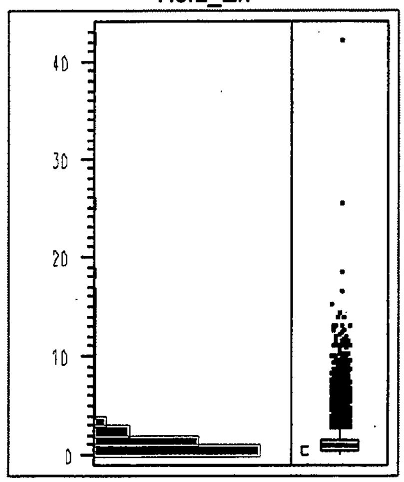
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	160.9942	3	59619	<.0001
Brown-Forsythe	1154.5767	3	59619	0.0000
Levene	1257.8525	3	59619	0.0000
Bartlett	10409.214	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
34.6228	3	14798	<.0001

Figure A.1- 10 Statistical Tests for Vertical Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet

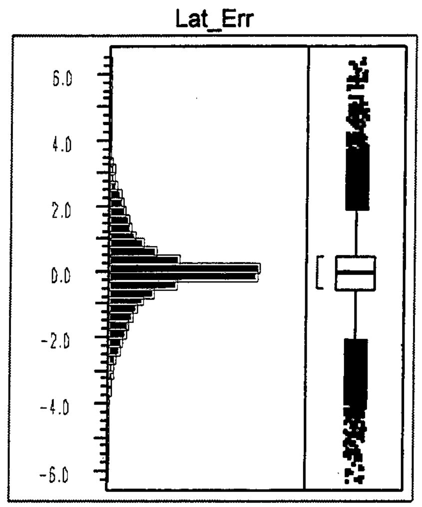
A.1.1.3 Histograms



Quantiles		
maximum	100.0%	42.390
	99.5%	6.717
	97.5%	3.499
	90.0%	2.374
quartile	75.0%	1.585
median	50.0%	0.961
quartile	25.0%	0.528
	10.0%	0.258
	2.5%	0.101
	0.5%	0.032
minimum	0.0%	0.000

Moments	
Mean	1.20
Std Dev	1.08
Std Error Mean	0.01
Upper 95% Mean	1.22
Lower 95% Mean	1.19
N	35928.00
Sum Weights	35928.00

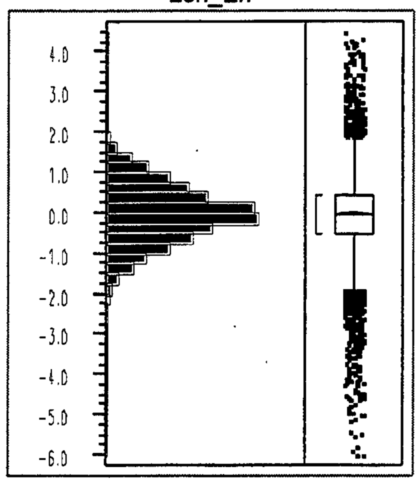
Figure A.1- 11 Histogram and Quantiles for Horizontal Error and Look Ahead Time 0 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	32.233
	99.5%	3.838
	97.5%	2.725
	90.0%	1.493
quartile	75.0%	0.483
median	50.0%	-0.003
quartile	25.0%	-0.531
	10.0%	-1.571
	2.5%	-2.761
	0.5%	-3.915
minimum	0.0%	-15.999

Moments	
Mean	-0.02
Std Dev	1.34
Std Error Mean	0.01
Upper 95% Mean	-0.01
Lower 95% Mean	-0.04
N	35928.00
Sum Weights	35928.00

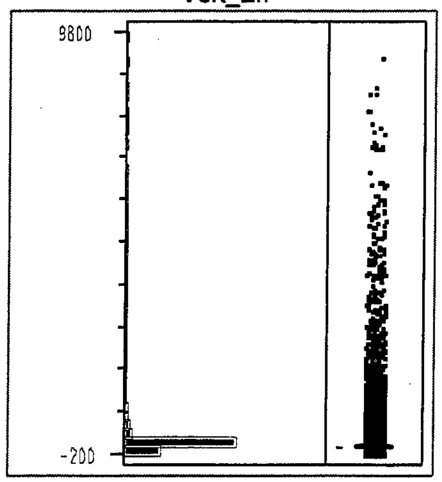
Figure A.1- 12 Histogram and Quantiles for Lateral Error and Look Ahead Time 0 for Samples at All Altitudes



Quantiles		
maximum	100.0%	11.926
	99.5%	2.393
	97.5%	1.461
	90.0%	0.948
quartile	75.0%	0.466
median	50.0%	-0.008
quartile	25.0%	-0.488
	10.0%	-0.970
	2.5%	-1.520
	0.5%	-2.549
minimum	0.0%	-27.532

Moments	
Mean	-0.02
Std Dev	0.91
Std Error Mean	0.00
Upper 95% Mean	-0.01
Lower 95% Mean	-0.03
N	35928.00
Sum Weights	35928.00

Figure A.1- 13 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 0 for Samples at All Altitudes



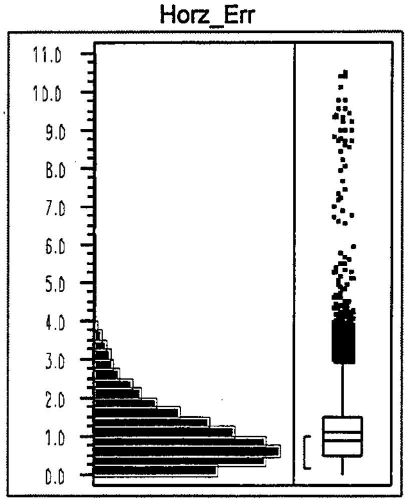
Quantiles

maximum	100.0%	36817
	99.5%	2831
	97.5%	1077
	90.0%	344
quartile	75.0%	24
median	50.0%	0
quartile	25.0%	0
	10.0%	-200
	2.5%	-832
	0.5%	-1513
minimum	0.0%	-6824

Moments

Mean	49.36
Std Dev	662.94
Std Error Mean	3.50
Upper 95% Mean	56.21
Lower 95% Mean	42.50
N	35928.00
Sum Weights	35928.00

Figure A.1- 14 Histogram and Quantiles for Vertical Error and Look Ahead Time 0 for Samples at All Altitudes



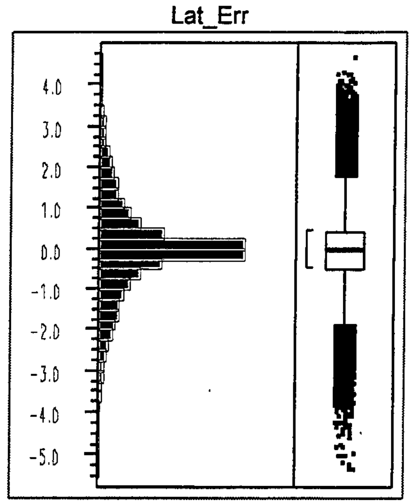
Quantiles

maximum	100.0%	42.390
	99.5%	4.092
	97.5%	3.242
	90.0%	2.266
quartile	75.0%	1.528
median	50.0%	0.938
quartile	25.0%	0.516
	10.0%	0.251
	2.5%	0.097
	0.5%	0.031
minimum	0.0%	0.000

Moments

Mean	1.14
Std Dev	0.94
Std Error Mean	0.01
Upper 95% Mean	1.15
Lower 95% Mean	1.13
N	26148.00
Sum Weights	26148.00

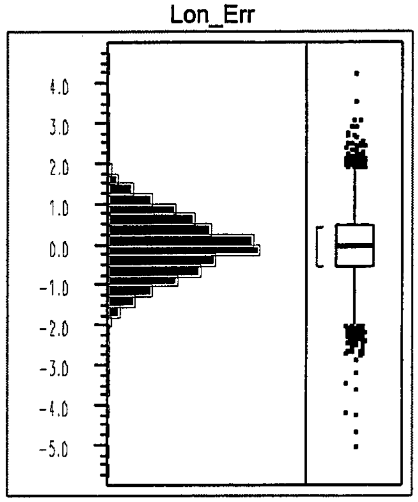
Figure A.1- 15 Histogram and Quantiles for Horizontal Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	32.233
	99.5%	3.470
	97.5%	2.578
	90.0%	1.403
quartile	75.0%	0.432
median	50.0%	-0.004
quartile	25.0%	-0.491
	10.0%	-1.515
	2.5%	-2.646
	0.5%	-3.547
minimum	0.0%	-6.035

Moments	
Mean	-0.02
Std Dev	1.20
Std Error Mean	0.01
Upper 95% Mean	-0.01
Lower 95% Mean	-0.04
N	26148.00
Sum Weights	26148.00

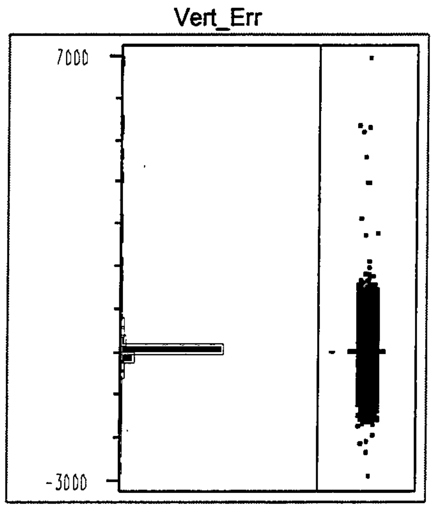
Figure A.1- 16 Histogram and Quantiles for Lateral Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	11.926
	99.5%	1.824
	97.5%	1.401
	90.0%	0.931
quartile	75.0%	0.468
median	50.0%	-0.016
quartile	25.0%	-0.510
	10.0%	-0.966
	2.5%	-1.451
	0.5%	-1.938
minimum	0.0%	-27.532

Moments	
Mean	-0.02
Std Dev	0.86
Std Error Mean	0.01
Upper 95% Mean	-0.01
Lower 95% Mean	-0.03
N	26148.00
Sum Weights	26148.00

Figure A.1- 17 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



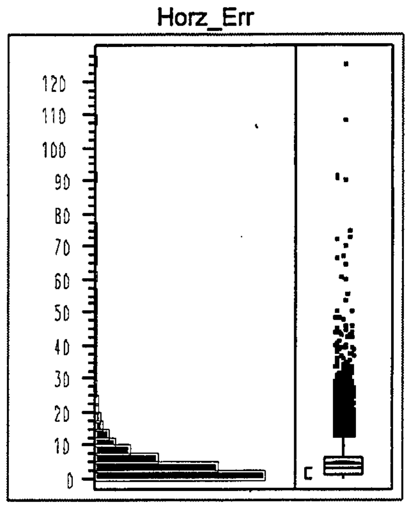
Quantiles

maximum	100.0%	36817
	99.5%	1315
	97.5%	889
	90.0%	200
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	0
	10.0%	-100
	2.5%	-607
	0.5%	-1101
minimum	0.0%	-2800

Moments

Mean	38.78
Std Dev	591.85
Std Error Mean	3.66
Upper 95% Mean	45.95
Lower 95% Mean	31.61
N	26148.00
Sum Weights	26148.00

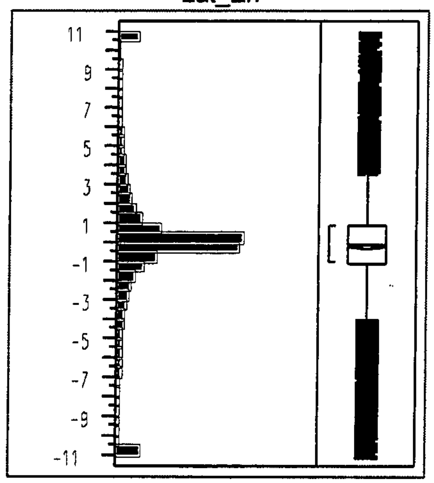
Figure A.1- 18 Histogram and Quantiles for Vertical Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Quantiles		
maximum	100.0%	125.68
	99.5%	29.29
	97.5%	19.31
	90.0%	11.40
quartile	75.0%	6.61
median	50.0%	3.41
quartile	25.0%	1.73
	10.0%	0.84
	2.5%	0.34
	0.5%	0.14
minimum	0.0%	0.02

Moments	
Mean	5.11
Std Dev	5.47
Std Error Mean	0.04
Upper 95% Mean	5.18
Lower 95% Mean	5.04
N	23964.00
Sum Weights	23964.00

Figure A.1- 19 Histogram and Quantiles for Horizontal Error and Look Ahead Time 600 for Samples at All Altitudes

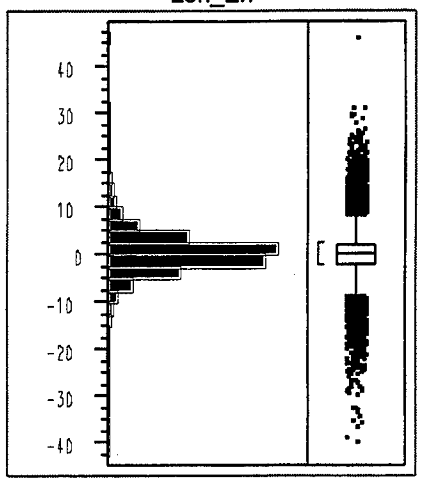


	Quantiles	
maximum	100.0%	97.448
	99.5%	20.990
	97.5%	11.379
	90.0%	4.208
quartile	75.0%	0.891
median	50.0%	-0.002
quartile	25.0%	-1.028
	10.0%	-5.083
	2.5%	-12.677
	0.5%	-21.637
minimum	0.0%	-61.740

Moments	
Mean	-0.17
Std Dev	5.43
Std Error Mean	0.04
Upper 95% Mean	-0.10
Lower 95% Mean	-0.24
N	23964.00
Sum Weights	23964.00

Figure A.1- 20 Histogram and Quantiles for Lateral Error and Look Ahead Time 600 for Samples at All Altitudes

Lon_Err



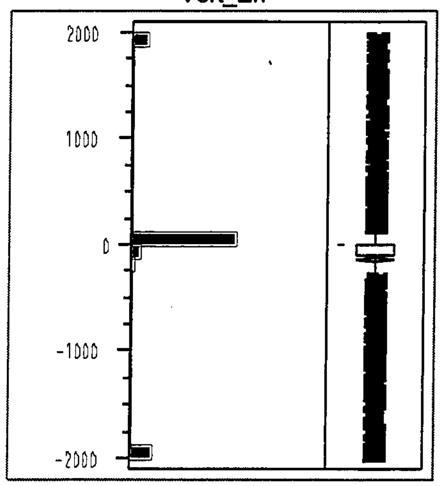
Quantiles

maximum	100.0%	91.729
	99.5%	18.430
	97.5%	11.242
	90.0%	5.349
quartile	75.0%	2.459
median	50.0%	0.264
quartile	25.0%	-1.891
	10.0%	-4.385
	2.5%	-9.435
	0.5%	-17.924
minimum	0.0%	-79.363

Moments

Mean	0.36
Std Dev	5.13
Std Error Mean	0.03
Upper 95% Mean	0.43
Lower 95% Mean	0.30
N	23964.00
Sum Weights	23964.00

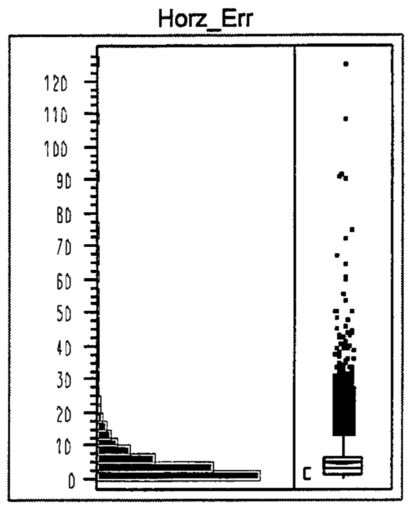
Figure A.1- 21 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 600 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	28933
	99.5%	8000
	97.5%	4300
	90.0%	1273
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-100
	10.0%	-2000
	2.5%	-4549
	0.5%	-7304
minimum	0.0%	-15374

Moments	
Mean	-126.58
Std Dev	1960.92
Std Error Mean	12.67
Upper 95% Mean	-101.75
Lower 95% Mean	-151.41
N	23964.00
Sum Weights	23964.00

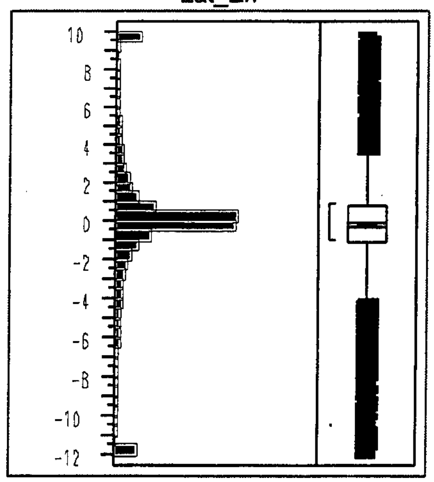
Figure A.1- 22 Histogram and Quantiles for Vertical Error and Look Ahead Time 600 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	125.68
	99.5%	30.02
	97.5%	20.02
	90.0%	11.96
quartile	75.0%	6.74
median	50.0%	3.39
quartile	25.0%	1.71
	10.0%	0.84
	2.5%	0.33
	0.5%	0.13
minimum	0.0%	0.02

Moments	
Mean	5.22
Std Dev	5.70
Std Error Mean	0.04
Upper 95% Mean	5.30
Lower 95% Mean	5.14
N	18210.00
Sum Weights	18210.00

Figure A.1- 23 Histogram and Quantiles for Horizontal Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

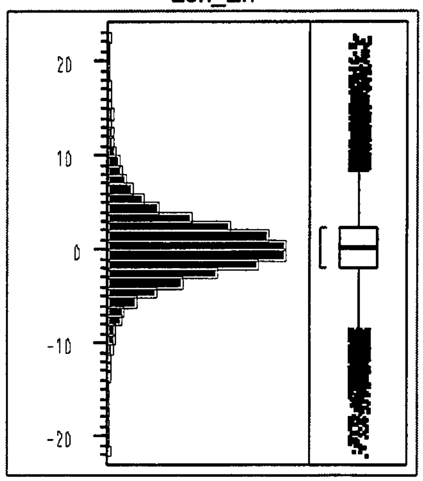


	Quantiles	
maximum	100.0%	97.448
	99.5%	21.986
	97.5%	12.112
	90.0%	4.455
quartile	75.0%	0.863
median	50.0%	-0.010
quartile	25.0%	-1.064
	10.0%	-5.616
	2.5%	-13.873
	0.5%	-22.433
minimum	0.0%	-61.740

Moments	
Mean	-0.23
Std Dev	5.82
Std Error Mean	0.04
Upper 95% Mean	-0.15
Lower 95% Mean	-0.32
N	18210.00
Sum Weights	18210.00

Figure A.1- 24 Histogram and Quantiles for Lateral Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

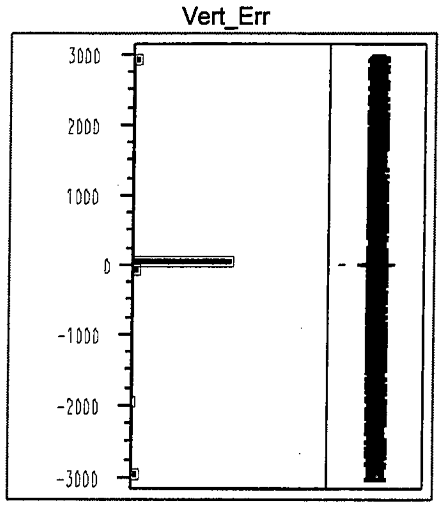
Lon_Err



	Quantiles	
maximum	100.0%	91.729
	99.5%	18.705
	97.5%	11.698
	90.0%	5.270
quartile	75.0%	2.406
median	50.0%	0.233
quartile	25.0%	-1.847
	10.0%	-4.153
	2.5%	-9.090
	0.5%	-17.506
minimum	0.0%	-79.363

Moments	
Mean	0.40
Std Dev	5.07
Std Error Mean	0.04
Upper 95% Mean	0.47
Lower 95% Mean	0.33
N	18210.00
Sum Weights	18210.00

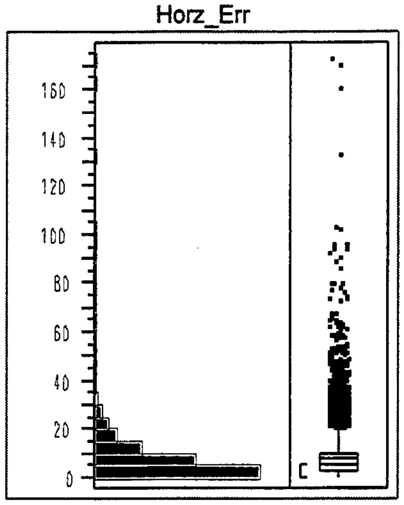
Figure A.1- 25 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	28933
	99.5%	8533
	97.5%	4420
	90.0%	1144
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	0
	10.0%	-1563
	2.5%	-4000
	0.5%	-6032
minimum	0.0%	-10552

Moments	
Mean	13.09
Std Dev	1819.69
Std Error Mean	13.48
Upper 95% Mean	39.53
Lower 95% Mean	-13.34
N	18210.00
Sum Weights	18210.00

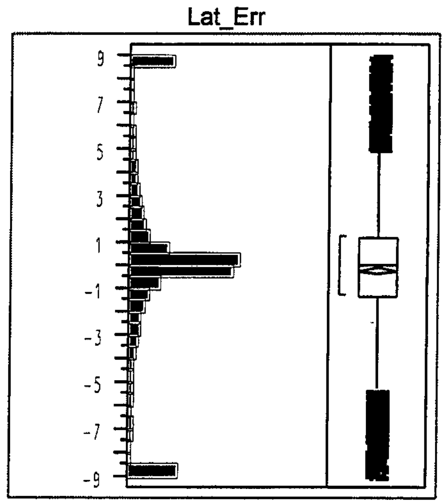
Figure A.1- 26 Histogram and Quantiles for Vertical Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	173.62
	99.5%	51.34
	97.5%	30.25
	90.0%	18.15
quartile	75.0%	10.56
median	50.0%	5.64
quartile	25.0%	2.85
	10.0%	1.34
	2.5%	0.52
	0.5%	0.22
minimum	0.0%	0.02

Moments	
Mean	8.25
Std Dev	8.89
Std Error Mean	0.08
Upper 95% Mean	8.40
Lower 95% Mean	8.10
N	13836.00
Sum Weights	13836.00

Figure A.1- 27 Histogram and Quantiles for Horizontal Error and Look Ahead Time 1200 for Samples at All Altitudes



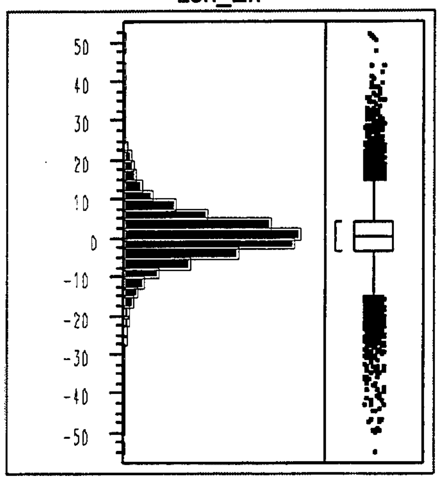
Quantiles

maximum	100.0%	134.87
	99.5%	30.74
	97.5%	16.67
	90.0%	6.21
quartile	75.0%	1.21
median	50.0%	0.01
quartile	25.0%	-1.36
	10.0%	-7.04
	2.5%	-18.78
	0.5%	-36.18
minimum	0.0%	-124.94

Moments

Mean	-0.21
Std Dev	8.41
Std Error Mean	0.07
Upper 95% Mean	-0.07
Lower 95% Mean	-0.35
N	13836.00
Sum Weights	13836.00

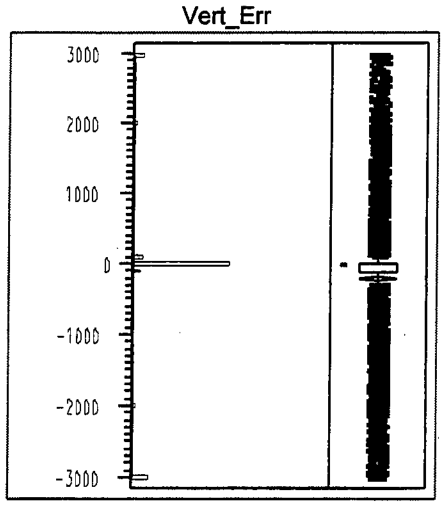
Figure A.1- 28 Histogram and Quantiles for Lateral Error and Look Ahead Time 1200 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	96.16
	99.5%	29.86
	97.5%	18.53
	90.0%	9.34
quartile	75.0%	4.50
median	50.0%	0.66
quartile	25.0%	-3.13
	10.0%	-7.55
	2.5%	-16.60
	0.5%	-30.62
minimum	0.0%	-109.33

Moments	
Mean	0.69
Std Dev	8.71
Std Error Mean	0.07
Upper 95% Mean	0.84
Lower 95% Mean	0.55
N	13836.00
Sum Weights	13836.00

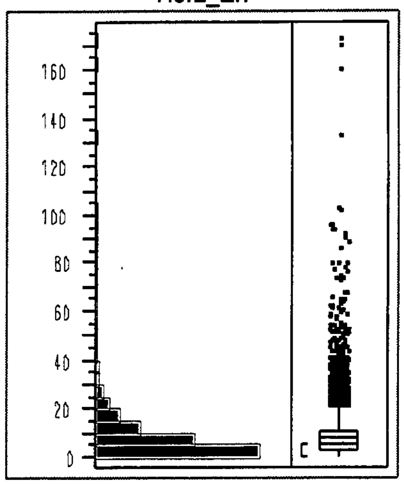
Figure A.1- 29 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 1200 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	37474
	99.5%	7774
	97.5%	4033
	90.0%	1235
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-100
	10.0%	-2459
	2.5%	-4933
	0.5%	-7560
minimum	0.0%	-15900

Moments	
Mean	-200.71
Std Dev	2113.70
Std Error Mean	17.97
Upper 95% Mean	-165.48
Lower 95% Mean	-235.93
N	13836.00
Sum Weights	13836.00

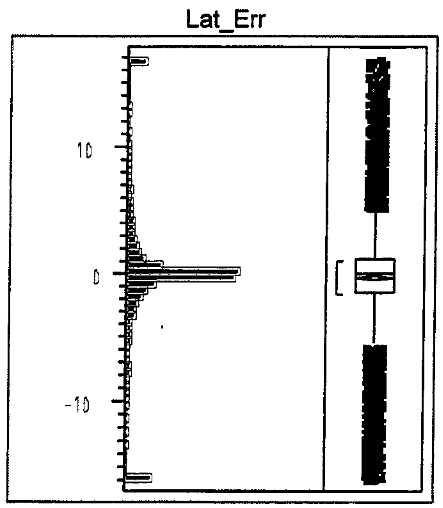
Figure A.1- 30 Histogram and Quantiles for Vertical Error and Look Ahead Time 1200 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	173.62
	99.5%	53.61
	97.5%	31.39
	90.0%	18.72
quartile	75.0%	10.80
median	50.0%	5.69
quartile	25.0%	2.90
	10.0%	1.35
	2.5%	0.50
	0.5%	0.21
minimum	0.0%	0.02

Moments	
Mean	8.45
Std Dev	9.32
Std Error Mean	0.09
Upper 95% Mean	8.63
Lower 95% Mean	8.27
N	10374.00
Sum Weights	10374.00

Figure A.1- 31 Histogram and Quantiles for Horizontal Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



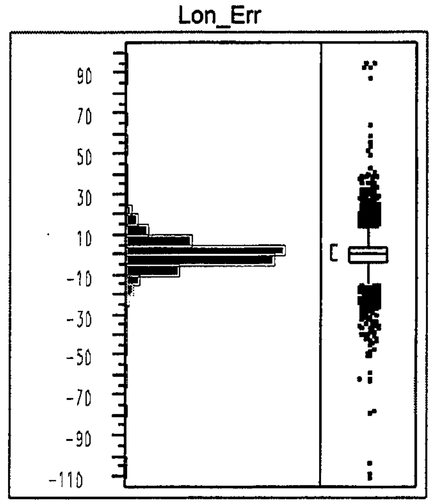
Quantiles

maximum	100.0%	134.87
	99.5%	33.48
	97.5%	18.17
	90.0%	7.16
quartile	75.0%	1.25
median	50.0%	0.01
quartile	25.0%	-1.44
	10.0%	-8.13
	2.5%	-20.01
	0.5%	-39.32
minimum	0.0%	-124.94

Moments

Mean	-0.27
Std Dev	9.18
Std Error Mean	0.09
Upper 95% Mean	-0.09
Lower 95% Mean	-0.44
N	10374.00
Sum Weights	10374.00

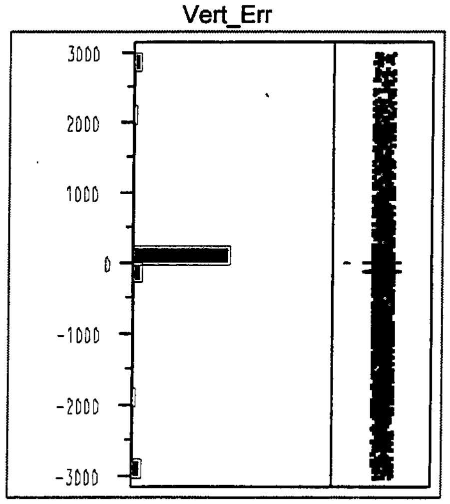
Figure A.1- 32 Histogram and Quantiles for Lateral Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	96.16
	99.5%	30.18
	97.5%	18.87
	90.0%	9.22
quartile	75.0%	4.39
median	50.0%	0.57
quartile	25.0%	-3.14
	10.0%	-7.08
	2.5%	-15.20
	0.5%	-29.10
minimum	0.0%	-109.33

Moments	
Mean	0.80
Std Dev	8.56
Std Error Mean	0.08
Upper 95% Mean	0.96
Lower 95% Mean	0.63
N	10374.00
Sum Weights	10374.00

Figure A.1- 33 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



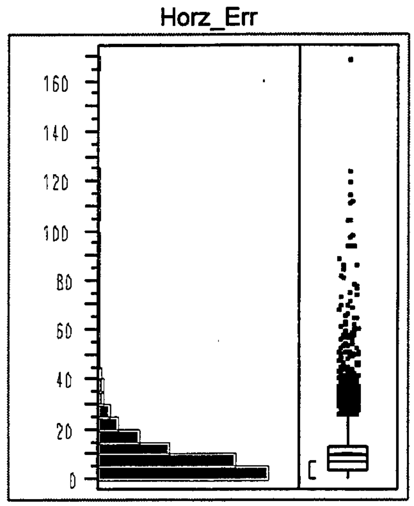
Quantiles

maximum	100.0%	37474
	99.5%	8000
	97.5%	4000
	90.0%	551
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	0
	10.0%	-2000
	2.5%	-4000
	0.5%	-6815
minimum	0.0%	-10486

Moments

Mean	-103.07
Std Dev	1926.20
Std Error Mean	18.91
Upper 95% Mean	-66.00
Lower 95% Mean	-140.14
N	10374.00
Sum Weights	10374.00

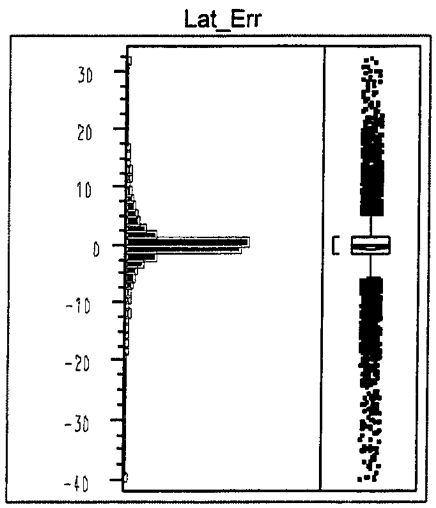
Figure A.1- 34 Histogram and Quantiles for Vertical Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	169.84
	99.5%	66.98
	97.5%	38.45
	90.0%	21.14
quartile	75.0%	13.00
median	50.0%	7.08
quartile	25.0%	3.64
	10.0%	1.78
	2.5%	0.72
	0.5%	0.33
minimum	0.0%	0.04

Moments	
Mean	10.167
Std Dev	10.898
Std Error Mean	0.136
Upper 95% Mean	10.433
Lower 95% Mean	9.901
N	6444.000
Sum Weights	6444.000

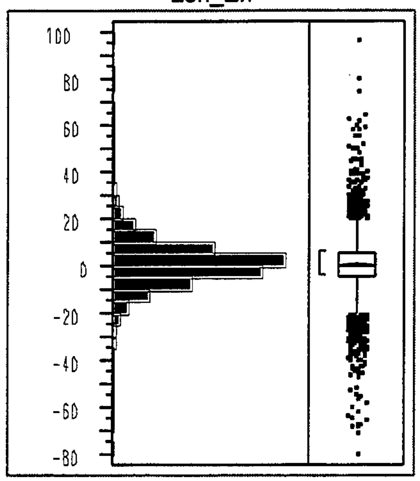
Figure A.1- 35 Histogram and Quantiles for Horizontal Error and Look Ahead Time 1800 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	117.09
	99.5%	36.81
	97.5%	17.96
	90.0%	7.08
quartile	75.0%	1.52
median	50.0%	0.03
quartile	25.0%	-1.31
	10.0%	-7.32
	2.5%	-20.59
	0.5%	-45.73
minimum	0.0%	-155.99

Moments	
Mean	-0.222
Std Dev	10.057
Std Error Mean	0.125
Upper 95% Mean	0.024
Lower 95% Mean	-0.467
N	6444.000
Sum Weights	6444.000

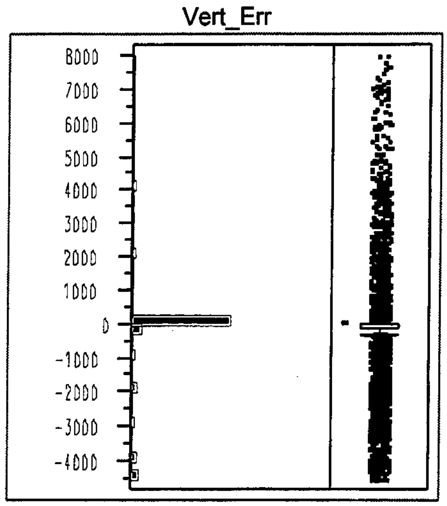
Figure A.1- 36 Histogram and Quantiles for Lateral Error and Look Ahead Time 1800 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	98.009
	99.5%	41.024
	97.5%	23.072
	90.0%	12.060
quartile	75.0%	5.899
median	50.0%	0.904
quartile	25.0%	-4.277
	10.0%	-10.251
	2.5%	-20.647
	0.5%	-39.811
minimum	0.0%	-78.525

Moments	
Mean	0.876
Std Dev	10.963
Std Error Mean	0.137
Upper 95% Mean	1.143
Lower 95% Mean	0.608
N	6444.000
Sum Weights	6444.000

Figure A.1- 37 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 1800 for Samples at All Altitudes



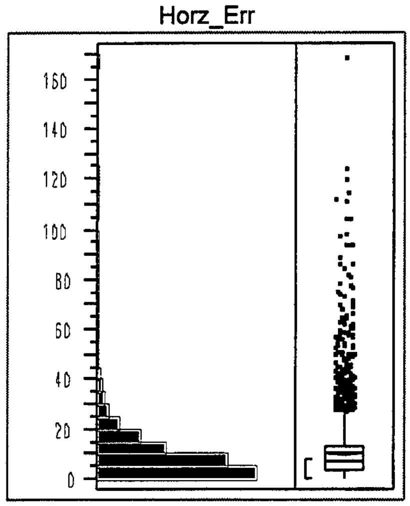
Quantiles

maximum	100.0%	31668
	99.5%	7732
	97.5%	4000
	90.0%	1100
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-100
	10.0%	-3100
	2.5%	-5699
	0.5%	-8000
minimum	0.0%	-15800

Moments

Mean	-327.149
Std Dev	2298.255
Std Error Mean	28.630
Upper 95% Mean	-271.024
Lower 95% Mean	-383.275
N	6444.000
Sum Weights	6444.000

Figure A.1- 38 Histogram and Quantiles for Vertical Error and Look Ahead Time 1800 for Samples at All Altitudes

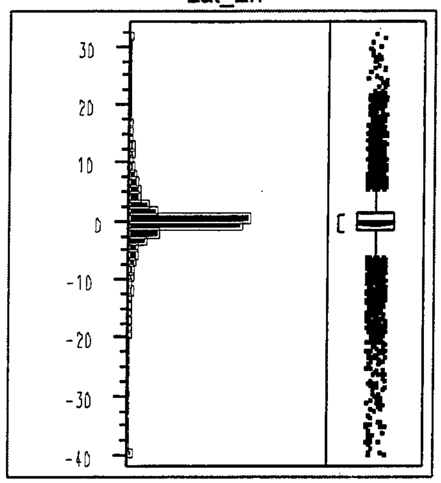


	Quantiles	
maximum	100.0%	169.84
	99.5%	74.93
	97.5%	39.65
	90.0%	21.87
quartile	75.0%	13.58
median	50.0%	7.32
quartile	25.0%	3.75
	10.0%	1.87
	2.5%	0.74
	0.5%	0.35
minimum	0.0%	0.04

Moments	
Mean	10.618
Std Dev	11.549
Std Error Mean	0.165
Upper 95% Mean	10.942
Lower 95% Mean	10.294
N	4891.000
Sum Weights	4891.000

Figure A.1- 39 Histogram and Quantiles for Horizontal Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

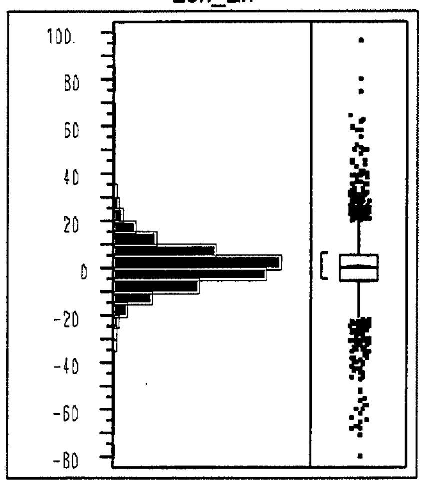
Lat_Err



	Quantiles	
maximum	100.0%	117.09
	99.5%	35.76
	97.5%	18.17
	90.0%	7.52
quartile	75.0%	1.51
median	50.0%	0.02
quartile	25.0%	-1.44
	10.0%	-8.47
	2.5%	-23.14
	0.5%	-51.61
minimum	0.0%	-155.99

Moments	
Mean	-0.444
Std Dev	10.750
Std. Error Mean	0.154
Upper 95% Mean	-0.143
Lower 95% Mean	-0.745
N	4891.000
Sum Weights	4891.000

Figure A.1- 40 Histogram and Quantiles for Lateral Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



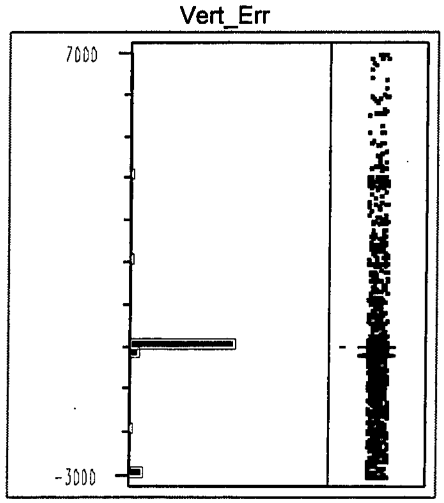
Quantiles

maximum	100.0%	98.009
	99.5%	43.388
	97.5%	24.060
	90.0%	12.093
quartile	75.0%	5.896
median	50.0%	0.674
quartile	25.0%	-4.559
	10.0%	-10.386
	2.5%	-21.096
	0.5%	-42.616
minimum	0.0%	-78.525

Moments

Mean	0.777
Std Dev	11.392
Std Error Mean	0.163
Upper 95% Mean	1.096
Lower 95% Mean	0.457
N	4891.000
Sum Weights	4891.000

Figure A.1- 41 Histogram and Quantiles for Longitudinal Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	31668
	99.5%	7405
	97.5%	4000
	90.0%	493
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	0
	10.0%	-2450
	2.5%	-4757
	0.5%	-7115
minimum	0.0%	-10550

Moments	
Mean	-180.173
Std Dev	2142.772
Std Error Mean	30.639
Upper 95% Mean	-120.105
Lower 95% Mean	-240.240
N	4891.000
Sum Weights	4891.000

Figure A.1- 42 Histogram and Quantiles for Vertical Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

A.1.2 Flight Type Per Look Ahead Time

A.1.2.1 Summary Tables

LOOKAHEAD TIME			0 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	19015	8448	7726	739
Avg. Horz. Error	1.15	1.31	1.22	1.39
Stddev. Horz. Error	0.96	1.4	0.91	1.4
Max. Horz. Error	42.39	16.91	11.93	12.94
Min. Horz. Error	0	0	0	0
Avg. Lat. Error	-0.04	0.03	-0.07	0.17
Stddev. Lat. Error	1.22	1.61	1.25	1.76
Max. Lat. Error	32.23	13.48	5.21	11.15
Min. Lat. Error	-6.04	-16	-5.18	-12.62
Avg. Abs. Lat. Error	0.81	0.94	0.92	1.13
Stddev. Abs. Lat. Error	0.91	1.31	0.85	1.37
Max. Abs. Lat. Error	32.23	16	5.21	12.62
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.03	-0.06	0.06	0
Stddev. Long. Error	0.87	1.03	0.86	0.87
Max. Long. Error	9.46	9.33	11.93	4.1
Min. Long. Error	-27.53	-9.81	-11.19	-4.93
Avg. Abs. Long. Error	0.59	0.67	0.58	0.58
Stddev. Abs. Long. Error	0.63	0.78	0.64	0.65
Max. Abs. Long. Error	27.53	9.81	11.93	4.93
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	32.35	70.19	61.55	121.23
Stddev. Vert. Error	499.73	925.09	660.83	758.4
Max. Vert. Error	26434.39	36817	28933	5907.7
Min. Vert. Error	-2264.79	-6824.15	-3113.24	-4200
Avg. Abs. Vert. Error	100.61	373.89	261.37	328.34
Stddev. Abs. Vert. Error	490.57	849.06	610.05	694.21
Max. Abs. Vert. Error	26434.39	36817	28933	5907.7
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	1.15	1.31	1.22	1.4
Stddev. Slant Range Error	0.96	1.4	0.91	1.4
Max. Slant Range Error	42.39	16.91	11.93	12.96
Min. Slant Range Error	0	0	0	0

Figure A.1- 43 Descriptive Statistics for Flight Types at Look Ahead Time of 0 and Samples at All Altitudes

LOOKAHEAD TIME			300 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	16297	6921	6011	570
Avg. Horz. Error	2.78	3.54	3.79	3.01
Stddev. Horz. Error	3.11	3.9	3.46	2.66
Max. Horz. Error	84.31	65.56	29.61	18.52
Min. Horz. Error	0.01	0.02	0.02	0.03
Avg. Lat. Error	-0.09	-0.06	-0.19	0.35
Stddev. Lat. Error	3.51	3.89	3.75	3.02
Max. Lat. Error	65.49	27.77	26.17	16.91
Min. Lat. Error	-36.73	-39.47	-23.37	-13.13
Avg. Abs. Lat. Error	1.87	2.1	2.14	1.89
Stddev. Abs. Lat. Error	2.97	3.27	3.09	2.38
Max. Abs. Lat. Error	65.49	39.47	26.17	16.91
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.02	-0.33	0.85	0.11
Stddev. Long. Error	2.24	3.53	3.38	2.63
Max. Long. Error	25.52	23.81	20.1	16.26
Min. Long. Error	-53.1	-65.39	-18.17	-12.89
Avg. Abs. Long. Error	1.51	2.25	2.48	1.83
Stddev. Abs. Long. Error	1.66	2.74	2.45	1.9
Max. Abs. Long. Error	53.1	65.39	20.1	16.26
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-64	-236.17	383.99	284.81
Stddev. Vert. Error	958.43	2204.25	2063.02	1864.12
Max. Vert. Error	14714.2	34817	14101	9842.23
Min. Vert. Error	-9667	-12626.9	-11900	-8383
Avg. Abs. Vert. Error	321.19	1349.62	1123.14	1023.72
Stddev. Abs. Vert. Error	905.27	1758.62	1772.53	1583.15
Max. Abs. Vert. Error	14714.2	34817	14101	9842.23
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	2.79	3.57	3.81	3.03
Stddev. Slant Range Error	3.1	3.89	3.45	2.66
Max. Slant Range Error	84.34	65.56	29.61	18.52
Min. Slant Range Error	0.01	0.04	0.06	0.07

Figure A.1- 44 Descriptive Statistics for Flight Types at Look Ahead Time of 300 and Samples at All Altitudes

LOOKAHEAD TIME			600 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	13704	5424	4416	420
Avg. Horz. Error	4.44	5.65	6.55	4.77
Stddev. Horz. Error	5.07	5.82	5.95	4.14
Max. Horz. Error	125.68	75.37	40.39	23.41
Min. Horz. Error	0.02	0.03	0.03	0.05
Avg. Lat. Error	-0.2	-0.05	-0.3	0.64
Stddev. Lat. Error	5.45	5.19	5.75	4.32
Max. Lat. Error	97.45	62.46	33.91	20.91
Min. Lat. Error	-56.31	-61.74	-37.42	-12.73
Avg. Abs. Lat. Error	2.82	2.77	3.16	2.59
Stddev. Abs. Lat. Error	4.67	4.39	4.81	3.51
Max. Abs. Lat. Error	97.45	62.46	37.42	20.91
Min. Abs. Lat. Error	0	0	0	0.01
Avg. Long. Error	0.05	-0.26	2.04	0.68
Stddev. Long. Error	3.95	6.24	6.4	4.52
Max. Long. Error	91.73	73.8	31.85	21.33
Min. Long. Error	-79.36	-75.35	-32.6	-14.82
Avg. Abs. Long. Error	2.54	4.07	4.75	3.21
Stddev. Abs. Long. Error	3.03	4.73	4.75	3.24
Max. Abs. Long. Error	91.73	75.35	32.6	21.33
Min. Abs. Long. Error	0	0	0	0.01
Avg. Vert. Error	-177.75	-508.57	473.21	169.75
Stddev. Vert. Error	1241.07	2752.91	2422.84	1934.9
Max. Vert. Error	20728.9	28933	20033	8000
Min. Vert. Error	-10000	-15373.8	-10295.8	-8500
Avg. Abs. Vert. Error	436.68	1826.53	1279.1	1087.2
Stddev. Abs. Vert. Error	1175.23	2121.4	2111.32	1608.69
Max. Abs. Vert. Error	20728.9	28933	20033	8500
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	4.45	5.69	6.57	4.78
Stddev. Slant Range Error	5.07	5.81	5.94	4.14
Max. Slant Range Error	125.72	75.37	40.39	23.41
Min. Slant Range Error	0.02	0.08	0.03	0.05

Figure A.1- 45 Descriptive Statistics for Flight Types at Look Ahead Time of 600 and Samples at All Altitudes

LOOKAHEAD TIME			900 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	11200	3996	3052	281
Avg. Horz. Error	6.01	7.47	9.01	6.14
Stddev. Horz. Error	6.89	7.29	8.25	4.99
Max. Horz. Error	167.79	92.08	71.45	22.86
Min. Horz. Error	0.02	0.05	0.06	0.09
Avg. Lat. Error	-0.31	0.13	-0.47	1.32
Stddev. Lat. Error	7.16	5.95	7.63	5.14
Max. Lat. Error	129.48	64.16	43.07	22.69
Min. Lat. Error	-94.55	-56.43	-71.04	-13.74
Avg. Abs. Lat. Error	3.62	3.17	4.07	3.16
Stddev. Abs. Lat. Error	6.19	5.04	6.48	4.26
Max. Abs. Lat. Error	129.48	64.16	71.04	22.69
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.13	-0.29	2.96	1.19
Stddev. Long. Error	5.67	8.57	9.05	5.76
Max. Long. Error	94.25	66.05	51.09	21.86
Min. Long. Error	-106.71	-70.79	-49.88	-16.05
Avg. Abs. Long. Error	3.63	5.74	6.71	4.24
Stddev. Abs. Long. Error	4.37	6.37	6.76	4.07
Max. Abs. Long. Error	106.71	70.79	51.09	21.86
Min. Abs. Long. Error	0	0	0	0.01
Avg. Vert. Error	-222.75	-437.71	271.32	56.89
Stddev. Vert. Error	1455.74	2965.71	2128.41	1880.16
Max. Vert. Error	30746.5	22083	15458.53	6881.69
Min. Vert. Error	-10050	-16419.3	-9797.11	-8383
Avg. Abs. Vert. Error	523.1	2001.31	1096.37	1143.82
Stddev. Abs. Vert. Error	1376.64	2231.77	1844.28	1491.74
Max. Abs. Vert. Error	30746.5	22083	15458.53	8383
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	6.02	7.5	9.02	6.16
Stddev. Slant Range Error	6.88	7.28	8.24	4.98
Max. Slant Range Error	167.86	92.08	71.45	22.86
Min. Slant Range Error	0.03	0.05	0.06	0.15

Figure A.1- 46 Descriptive Statistics for Flight Types at Look Ahead Time of 900 and Samples at All Altitudes

LOOKAHEAD TIME		1200 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	8886	2752	2023	175
Avg. Horz. Error	7.4	8.89	11.2	6.85
Stddev. Horz. Error	8.41	8.69	10.58	4.94
Max. Horz. Error	173.62	78	93.06	22.45
Min. Horz. Error	0.02	0.11	0.05	0.26
Avg. Lat. Error	-0.34	0.45	-0.78	2.14
Stddev. Lat. Error	8.56	6.91	9.66	4.82
Max. Lat. Error	134.87	53.61	46.16	18.81
Min. Lat. Error	-124.94	-61.74	-91.33	-11.86
Avg. Abs. Lat. Error	4.23	3.46	4.86	3.38
Stddev. Abs. Lat. Error	7.45	6	8.38	4.05
Max. Abs. Lat. Error	134.87	61.74	91.33	18.81
Min. Abs. Lat. Error	0	0	0	0.01
Avg. Long. Error	0.32	-0.24	3.57	1.29
Stddev. Long. Error	7.22	10.32	11.44	6.48
Max. Long. Error	96.16	52.72	65.93	21.87
Min. Long. Error	-109.33	-77.99	-62.47	-16.17
Avg. Abs. Long. Error	4.71	7.06	8.43	5.06
Stddev. Abs. Long. Error	5.48	7.54	8.52	4.24
Max. Abs. Long. Error	109.33	77.99	65.93	21.87
Min. Abs. Long. Error	0	0.01	0	0.03
Avg. Vert. Error	-237.76	-266.5	32.54	19.2
Stddev. Vert. Error	1722.27	3142.5	1905.68	2148.85
Max. Vert. Error	37473.73	16051.78	12600.17	5740.39
Min. Vert. Error	-12399.1	-15900	-10713.8	-8500
Avg. Abs. Vert. Error	633.63	2172.19	913.39	1384.14
Stddev. Abs. Vert. Error	1619.02	2286.1	1672.71	1640.45
Max. Abs. Vert. Error	37473.73	16051.78	12600.17	8500
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	7.41	8.92	11.2	6.86
Stddev. Slant Range Error	8.41	8.68	10.58	4.93
Max. Slant Range Error	173.7	78.01	93.06	22.45
Min. Slant Range Error	0.02	0.14	0.05	0.33

Figure A.1- 47 Descriptive Statistics for Flight Types at Look Ahead Time of 1200 and Samples at All Altitudes

LOOKAHEAD TIME			1500 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	6640	1694	1243	101
Avg. Horz. Error	8.56	9.92	13.03	7.01
Stddev. Horz. Error	9.56	9.65	12.6	4.64
Max. Horz. Error	156.35	67.23	111.55	17.63
Min. Horz. Error	0.01	0.14	0.11	0.09
Avg. Lat. Error	-0.42	0.97	-1.18	2.56
Stddev. Lat. Error	9.56	8.28	10.73	3.96
Max. Lat. Error	120.34	65.64	57.15	16.08
Min. Lat. Error	-143.49	-49.76	-85.38	-3.86
Avg. Abs. Lat. Error	4.59	4.09	5.3	3
Stddev. Abs. Lat. Error	8.39	7.26	9.4	3.64
Max. Abs. Lat. Error	143.49	65.64	85.38	16.08
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.34	0.14	4.1	0.85
Stddev. Long. Error	8.55	11.05	13.98	6.93
Max. Long. Error	97.63	45.17	81.43	14.52
Min. Long. Error	-99.82	-56.73	-71.79	-17.58
Avg. Abs. Long. Error	5.72	7.67	10.26	5.5
Stddev. Abs. Long. Error	6.37	7.95	10.35	4.27
Max. Abs. Long. Error	99.82	56.73	81.43	17.58
Min. Abs. Long. Error	0	0	0	0.03
Avg. Vert. Error	-276.73	-380.65	-114.87	-226.58
Stddev. Vert. Error	1926.48	3273.2	1894.15	1874.91
Max. Vert. Error	38907.87	13000	10800.18	4711.27
Min. Vert. Error	-11065.7	-17219.3	-8000	-8383
Avg. Abs. Vert. Error	766.3	2367.34	882.97	1161.07
Stddev. Abs. Vert. Error	1789.03	2291.55	1679.51	1485.11
Max. Abs. Vert. Error	38907.87	17219.3	10800.18	8383
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	8.57	9.95	13.04	7.02
Stddev. Slant Range Error	9.56	9.64	12.6	4.64
Max. Slant Range Error	156.48	67.26	111.55	17.63
Min. Slant Range Error	0.01	0.16	0.11	0.21

Figure A.1- 48 Descriptive Statistics for Flight Types at Look Ahead Time of 1500 and Samples at All Altitudes

	LOOKAHEAD TIME		1800 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	4686	923	774	61
Avg. Horz. Error	9.46	10.3	14.38	8.64
Stddev. Horz. Error	10.33	10.3	13.92	5.68
Max. Horz. Error	169.84	72.73	112.98	21.74
Min. Horz. Error	0.04	0.22	0.15	1.21
Avg. Lat. Error	-0.48	1.85	-1.31	2.45
Stddev. Lat. Error	10.09	9.36	10.66	2.84
Max. Lat. Error	117.09	72.43	28.96	10.43
Min. Lat. Error	-155.99	-39.14	-91.1	-1.15
Avg. Abs. Lat. Error	4.72	4.61	5.24	2.53
Stddev. Abs. Lat. Error	8.93	8.35	9.37	2.77
Max. Abs. Lat. Error	155.99	72.43	91.1	10.43
Min. Abs. Lat. Error	0	0	0	0.06
Avg. Long. Error	0.21	1.08	4.63	1.35
Stddev. Long. Error	9.7	10.96	16.25	9.6
Max. Long. Error	98.01	41.28	81.38	16.86
Min. Long. Error	-78.53	-64.35	-66.82	-19.44
Avg. Abs. Long. Error	6.62	7.74	11.85	7.81
Stddev. Abs. Long. Error	7.09	7.83	12.03	5.66
Max. Abs. Long. Error	98.01	64.35	81.38	19.44
Min. Abs. Long. Error	0	0.02	0.01	0.46
Avg. Vert. Error	-306.19	-554.83	-193.89	-182.77
Stddev. Vert. Error	2109.86	3315.83	1909.9	1606.16
Max. Vert. Error	31668.16	14399.68	8660.28	2772.54
Min. Vert. Error	-12044.6	-15800	-8416.04	-5355.93
Avg. Abs. Vert. Error	882.07	2398.38	867.36	1093.59
Stddev. Abs. Vert. Error	1940.89	2354.66	1712.32	1182.3
Max. Abs. Vert. Error	31668.16	15800	8660.28	5355.93
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	9.48	10.32	14.39	8.65
Stddev. Slant Range Error	10.32	10.29	13.91	5.68
Max. Slant Range Error	169.84	72.73	112.98	21.75
Min. Slant Range Error	0.04	0.23	0.15	1.21

Figure A.1- 49 Descriptive Statistics for Flight Types at Look Ahead Time of 1800 and Samples at All Altitudes

LOOKAHEAD TIME			0 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	17817	4349	3954	28
Avg. Horz. Error	1.15	1.05	1.19	0.72
Stddev. Horz. Error	0.98	0.78	0.95	0.53
Max. Horz. Error	42.39	5.75	11.93	1.97
Min. Horz. Error	0	0	0	0.09
Avg. Lat. Error	-0.03	0.02	-0.08	0.2
Stddev. Lat. Error	1.22	1.09	1.21	0.52
Max. Lat. Error	32.23	4.06	5.21	1.93
Min. Lat. Error	-6.04	-5.33	-5.18	-1.34
Avg. Abs. Lat. Error	0.81	0.74	0.86	0.34
Stddev. Abs. Lat. Error	0.92	0.8	0.85	0.44
Max. Abs. Lat. Error	32.23	5.33	5.21	1.93
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.03	-0.08	0.06	-0.01
Stddev. Long. Error	0.88	0.71	0.93	0.71
Max. Long. Error	9.46	4.3	11.93	1.59
Min. Long. Error	-27.53	-4.6	-11.19	-1.16
Avg. Abs. Long. Error	0.6	0.55	0.61	0.54
Stddev. Abs. Long. Error	0.64	0.46	0.71	0.45
Max. Abs. Long. Error	27.53	4.6	11.93	1.59
Min. Abs. Long. Error	0	0	0	0.01
Avg. Vert. Error	32.33	33.57	73.39	65.94
Stddev. Vert. Error	510.26	678.37	796.74	408.62
Max. Vert. Error	26434.39	36817	28933	1055.33
Min. Vert. Error	-2264.79	-2045.36	-2800	-817.64
Avg. Abs. Vert. Error	97.56	210.85	232.04	226.69
Stddev. Abs. Vert. Error	501.89	645.64	765.72	343.78
Max. Abs. Vert. Error	26434.39	36817	28933	1055.33
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	1.15	1.05	1.2	0.72
Stddev. Slant Range Error	0.98	0.78	0.96	0.53
Max. Slant Range Error	42.39	6.06	11.93	1.97
Min. Slant Range Error	0	0	0	0.09

Figure A.1- 50 Descriptive Statistics for Flight Types at Look Ahead Time of 0 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME		300 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	15321	3239	3913	27
Avg. Horz. Error	2.83	3.66	4.16	3.34
Stddev. Horz. Error	3.17	4.6	3.68	2.56
Max. Horz. Error	84.31	65.56	29.61	9.35
Min. Horz. Error	0.01	0.02	0.02	0.03
Avg. Lat. Error	-0.07	-0.13	-0.31	0.16
Stddev. Lat. Error	3.59	4.42	4.05	1.01
Max. Lat. Error	65.49	27.77	26.17	2.21
Min. Lat. Error	-36.73	-39.47	-23.37	-2.91
Avg. Abs. Lat. Error	1.91	2.28	2.26	0.64
Stddev. Abs. Lat. Error	3.05	3.79	3.37	0.79
Max. Abs. Lat. Error	65.49	39.47	26.17	2.91
Min. Abs. Lat. Error	0	0	0	0.01
Avg. Long. Error	-0.02	-0.36	1.1	1.76
Stddev. Long. Error	2.27	3.86	3.62	3.73
Max. Long. Error	25.52	23.81	20.1	9.35
Min. Long. Error	-53.1	-65.39	-16.88	-4.1
Avg. Abs. Long. Error	1.53	2.22	2.78	3.11
Stddev. Abs. Long. Error	1.68	3.19	2.58	2.65
Max. Abs. Long. Error	53.1	65.39	20.1	9.35
Min. Abs. Long. Error	0	0	0	0.01
Avg. Vert. Error	-62.08	198.19	402.09	2824.39
Stddev. Vert. Error	955.2	2171.12	2092.56	3199.69
Max. Vert. Error	14714.2	34817	14101	9842.23
Min. Vert. Error	-9667	-9892.71	-10304.6	-1000
Avg. Abs. Vert. Error	317.63	1226.61	1151.8	3036.92
Stddev. Abs. Vert. Error	902.98	1802.22	1792.63	2990.73
Max. Abs. Vert. Error	14714.2	34817	14101	9842.23
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	2.84	3.69	4.18	3.48
Stddev. Slant Range Error	3.17	4.59	3.67	2.46
Max. Slant Range Error	84.34	65.56	29.61	9.35
Min. Slant Range Error	0.01	0.04	0.06	0.88

Figure A.1- 51 Descriptive Statistics for Flight Types at Look Ahead Time of 300 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME			600 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	12874	2180	3140	16
Avg. Horz. Error	4.55	5.87	7.51	7.05
Stddev. Horz. Error	5.18	6.7	6.32	6.02
Max. Horz. Error	125.68	75.37	40.39	19.11
Min. Horz. Error	0.02	0.05	0.03	0.56
Avg. Lat. Error	-0.18	-0.17	-0.52	0.7
Stddev. Lat. Error	5.59	6.26	6.37	1.85
Max. Lat. Error	97.45	62.46	33.91	6.81
Min. Lat. Error	-56.31	-61.74	-37.42	-1.68
Avg. Abs. Lat. Error	2.9	3.27	3.56	1.02
Stddev. Abs. Lat. Error	4.79	5.34	5.3	1.68
Max. Abs. Lat. Error	97.45	62.46	37.42	6.81
Min. Abs. Lat. Error	0	0	0	0.01
Avg. Long. Error	0.04	-0.55	2.5	4.59
Stddev. Long. Error	4.02	6.3	7.02	7.93
Max. Long. Error	91.73	26.87	31.85	19.01
Min. Long. Error	-79.36	-75.35	-28.52	-4.76
Avg. Abs. Long. Error	2.59	3.89	5.48	6.85
Stddev. Abs. Long. Error	3.08	4.99	5.05	5.94
Max. Abs. Long. Error	91.73	75.35	31.85	19.01
Min. Abs. Long. Error	0	0	0	0.52
Avg. Vert. Error	-168.77	175.38	627.24	3707.17
Stddev. Vert. Error	1227.7	2729.41	2684.06	3264.89
Max. Vert. Error	20728.9	28933	20033	8000
Min. Vert. Error	-10000	-10552	-9233	-1000
Avg. Abs. Vert. Error	426.3	1703.61	1525.93	3934.42
Stddev. Abs. Vert. Error	1163.61	2139.35	2295.33	2967.69
Max. Abs. Vert. Error	20728.9	28933	20033	8000
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	4.56	5.9	7.53	7.16
Stddev. Slant Range Error	5.18	6.68	6.31	5.94
Max. Slant Range Error	125.72	75.37	40.39	19.11
Min. Slant Range Error	0.02	0.08	0.03	0.7

Figure A.1- 52 Descriptive Statistics for Flight Types at Look Ahead Time of 600 and Samples at Altitudes Above 18,000 Feet

	LOOKAHEAD TIME		900 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	10484	1330	2151	7
Avg. Horz. Error	6.18	7.69	10.51	5.47
Stddev. Horz. Error	7.05	8.61	8.73	7.42
Max. Horz. Error	167.79	92.08	71.45	21.97
Min. Horz. Error	0.03	0.06	0.09	0.98
Avg. Lat. Error	-0.26	0.34	-0.75	0.74
Stddev. Lat. Error	7.36	7.41	8.66	0.76
Max. Lat. Error	129.48	64.16	43.07	2.13
Min. Lat. Error	-94.55	-56.43	-71.04	-0.03
Avg. Abs. Lat. Error	3.74	3.9	4.77	0.75
Stddev. Abs. Lat. Error	6.34	6.31	7.27	0.75
Max. Abs. Lat. Error	129.48	64.16	71.04	2.13
Min. Abs. Lat. Error	0	0	0	0.03
Avg. Long. Error	0.12	-1	3.55	2.14
Stddev. Long. Error	5.79	8.79	9.93	9.14
Max. Long. Error	94.25	66.05	51.09	21.86
Min. Long. Error	-106.71	-70.79	-42.99	-4.77
Avg. Abs. Long. Error	3.7	5.35	7.79	5.4
Stddev. Abs. Long. Error	4.45	7.04	7.11	7.41
Max. Abs. Long. Error	106.71	70.79	51.09	21.86
Min. Abs. Long. Error	0	0	0	0.98
Avg. Vert. Error	-199.89	438.42	409.32	5089.34
Stddev. Vert. Error	1437.65	3093.88	2395.8	1556.09
Max. Vert. Error	30746.5	22083	15458.53	6881.69
Min. Vert. Error	-9700	-10700	-9797.11	3000
Avg. Abs. Vert. Error	504.46	2025.65	1333.17	5089.34
Stddev. Abs. Vert. Error	1361	2378.67	2032.07	1556.09
Max. Abs. Vert. Error	30746.5	22083	15458.53	6881.69
Min. Abs. Vert. Error	0	0	0	3000
Avg. Slant Range Error	6.19	7.72	10.53	5.65
Stddev. Slant Range Error	7.04	8.6	8.72	7.33
Max. Slant Range Error	167.86	92.08	71.45	21.97
Min. Slant Range Error	0.03	0.11	0.09	1.38

Figure A.1- 53 Descriptive Statistics for Flight Types at Look Ahead Time of 900 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME		1200 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	8279	729	1365	1
Avg. Horz. Error	7.6	8.71	13.43	2.45
Stddev. Horz. Error	8.61	10.08	11.25	0
Max. Horz. Error	173.62	78	93.06	2.45
Min. Horz. Error	0.02	0.16	0.05	2.45
Avg. Lat. Error	-0.27	1.56	-1.21	0.44
Stddev. Lat. Error	8.81	8.46	11.38	0
Max. Lat. Error	134.87	53.61	46.16	0.44
Min. Lat. Error	-124.94	-61.74	-91.33	0.44
Avg. Abs. Lat. Error	4.37	4.43	6.06	0.44
Stddev. Abs. Lat. Error	7.65	7.37	9.7	0
Max. Abs. Lat. Error	134.87	61.74	91.33	0.44
Min. Abs. Lat. Error	0	0	0	0.44
Avg. Long. Error	0.3	-0.39	4.48	-2.41
Stddev. Long. Error	7.37	10.18	12.49	0
Max. Long. Error	96.16	52.53	65.93	-2.41
Min. Long. Error	-109.33	-77.99	-46.22	-2.41
Avg. Abs. Long. Error	4.82	6.06	9.88	2.41
Stddev. Abs. Long. Error	5.59	8.18	8.85	0
Max. Abs. Long. Error	109.33	77.99	65.93	2.41
Min. Abs. Long. Error	0	0.01	0	2.41
Avg. Vert. Error	-198.02	579.37	104.24	5507.95
Stddev. Vert. Error	1698.4	3291.49	2134.86	0
Max. Vert. Error	37473.73	16051.78	12600.17	5507.95
Min. Vert. Error	-8800	-9350	-10485.7	5507.95
Avg. Abs. Vert. Error	605.09	2138.76	1086.58	5507.95
Stddev. Abs. Vert. Error	1599.25	2567	1840.37	0
Max. Abs. Vert. Error	37473.73	16051.78	12600.17	5507.95
Min. Abs. Vert. Error	0	0	0	5507.95
Avg. Slant Range Error	7.61	8.75	13.43	2.61
Stddev. Slant Range Error	8.61	10.06	11.25	0
Max. Slant Range Error	173.7	78.01	93.06	2.61
Min. Slant Range Error	0.02	0.16	0.05	2.61

Figure A.1- 54 Descriptive Statistics for Flight Types at Look Ahead Time of 1200 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME		1500 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	6125	385	797	0
Avg. Horz. Error	8.81	9.26	16.24	0
Stddev. Horz. Error	9.83	10.56	13.8	0
Max. Horz. Error	156.35	67.23	111.55	0
Min. Horz. Error	0.01	0.22	0.16	0
Avg. Lat. Error	-0.34	2.24	-1.99	0
Stddev. Lat. Error	9.87	9.38	12.89	0
Max. Lat. Error	120.34	65.64	57.15	0
Min. Lat. Error	-143.49	-49.76	-85.38	0
Avg. Abs. Lat. Error	4.75	4.81	6.85	0
Stddev. Abs. Lat. Error	8.66	8.35	11.1	0
Max. Abs. Lat. Error	143.49	65.64	85.38	0
Min. Abs. Lat. Error	0	0.02	0	0
Avg. Long. Error	0.31	0.18	5.52	0
Stddev. Long. Error	8.76	10.22	15.94	0
Max. Long. Error	97.63	36.7	81.43	0
Min. Long. Error	-99.82	-56.73	-71.79	0
Avg. Abs. Long. Error	5.86	6.36	12.58	0
Stddev. Abs. Long. Error	6.52	8	11.22	0
Max. Abs. Long. Error	99.82	56.73	81.43	0
Min. Abs. Long. Error	0	0.01	0.07	0
Avg. Vert. Error	-221.3	640.74	-159.15	0
Stddev. Vert. Error	1908.58	3153.86	2153.44	0
Max. Vert. Error	38907.87	13000	10800.18	0
Min. Vert. Error	-9483.61	-7073.06	-7833	0
Avg. Abs. Vert. Error	729.55	2145.71	1053.36	0
Stddev. Abs. Vert. Error	1777.45	2396.32	1884.6	0
Max. Abs. Vert. Error	38907.87	13000	10800.18	0
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	8.82	9.29	16.25	0
Stddev. Slant Range Error	9.83	10.54	13.8	0
Max. Slant Range Error	156.48	67.26	111.55	0
Min. Slant Range Error	0.01	0.22	0.16	0

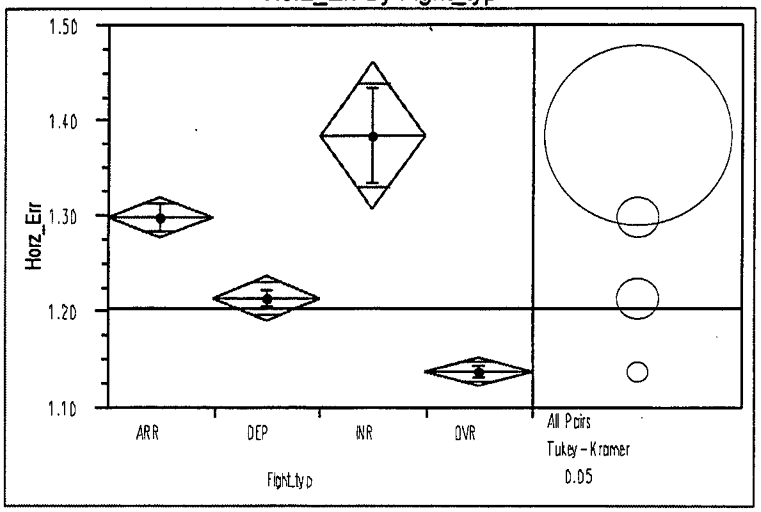
Figure A.1- 55 Descriptive Statistics for Flight Types at Look Ahead Time of 1500 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME		1800 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	4246	192	453	0
Avg. Horz. Error	9.77	9.89	18.89	0
Stddev. Horz. Error	10.69	11.35	15.51	0
Max. Horz. Error	169.84	65.77	112.98	0
Min. Horz. Error	0.04	0.28	0.19	0
Avg. Lat. Error	-0.36	2.46	-2.42	0
Stddev. Lat. Error	10.48	9.21	13.26	0
Max. Lat. Error	117.09	53.61	28.96	0
Min. Lat. Error	-155.99	-12.52	-91.1	0
Avg. Abs. Lat. Error	4.88	4.87	7.05	0
Stddev. Abs. Lat. Error	9.28	8.19	11.49	0
Max. Abs. Lat. Error	155.99	53.61	91.1	0
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.12	-0.28	7.36	0
Stddev. Long. Error	9.99	11.67	19.03	0
Max. Long. Error	98.01	41.28	81.38	0
Min. Long. Error	-78.53	-64.35	-66.82	0
Avg. Abs. Long. Error	6.82	6.8	15.42	0
Stddev. Abs. Long. Error	7.29	9.47	13.34	0
Max. Abs. Long. Error	98.01	64.35	81.38	0
Min. Abs. Long. Error	0	0.1	0.01	0
Avg. Vert. Error	-214.25	915.07	-325	0
Stddev. Vert. Error	2071.27	3306.58	2054.36	0
Max. Vert. Error	31668.16	14399.68	8660.28	0
Min. Vert. Error	-10550	-5633	-7900	0
Avg. Abs. Vert. Error	823.12	2281.02	964.54	0
Stddev. Abs. Vert. Error	1912.69	2558.31	1842.24	0
Max. Abs. Vert. Error	31668.16	14399.68	8660.28	0
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	9.78	9.92	18.89	0
Stddev. Slant Range Error	10.68	11.34	15.51	0
Max. Slant Range Error	169.84	65.81	112.98	0
Min. Slant Range Error	0.04	0.69	0.39	0

Figure A.1- 56 Descriptive Statistics for Flight Types at Look Ahead Time of 1800 and Samples at Altitudes Above 18,000 Feet

A.1.2.2 Statistical Tests

Horz_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	8448	1.30677	1.39839	0.01521
DEP	7726	1.21862	0.91280	0.01038
INR	739	1.39209	1.39924	0.05147
OVR	19015	1.14659	0.96289	0.00698

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.000000	0.085314	0.173462	0.245493
ARR	-0.08531	0.000000	0.088149	0.160180
DEP	-0.17346	-0.08815	0.000000	0.072031
OVR	-0.24549	-0.16018	-0.07203	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56915

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-0.14456	-0.02129	0.066462	0.141303
ARR	-0.02129	-0.04276	0.044404	0.123845
DEP	0.066462	0.044404	-0.04471	0.034540
OVR	0.141303	0.123845	0.034540	-0.0285

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	8448	1.398387	0.8735268	0.8128893
DEP	7726	0.912805	0.6773466	0.6614614
INR	739	1.399239	0.8921797	0.8410334
OVR	19015	0.962894	0.6522515	0.6309438

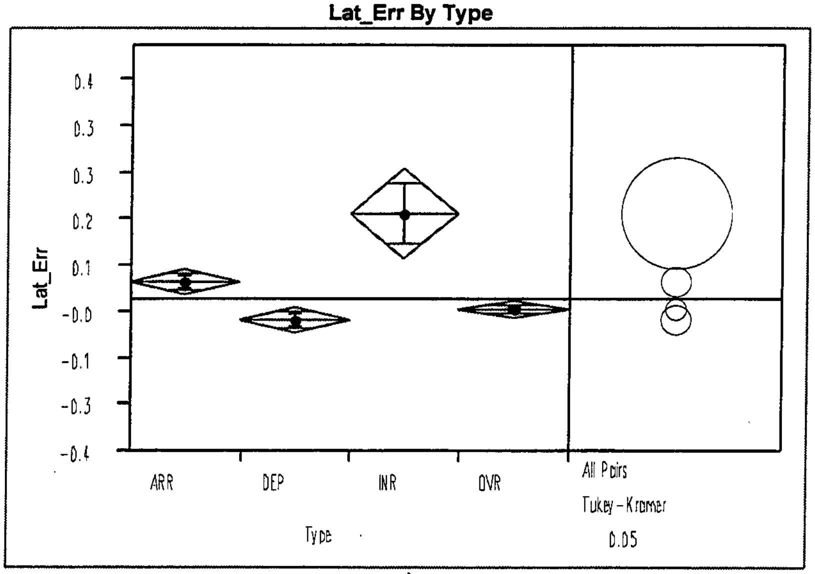
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	20.6626	3	35924	<.0001
Brown-Forsythe	94.8825	3	35924	<.0001
Levene	164.7150	3	35924	<.0001
Bartlett	774.7981	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
40.1530	3	3346.9	<.0001

Figure A.1- 57 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 0 for Samples at All Altitudes

Lat_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	8448	0.027652	1.61241	0.01754
DEP	7726	-0.0661	1.25060	0.01423
INR	739	0.172656	1.76404	0.06489
OVR	19015	-0.03539	1.22071	0.00885

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	OVR	DEP
INR	0.000000	0.145004	0.208051	0.238760
ARR	-0.145	0.000000	0.063046	0.093756
OVR	-0.20805	-0.06305	0.000000	0.030710
DEP	-0.23876	-0.09376	-0.03071	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56915

Abs(Dif)-LSD	INR	ARR	OVR	DEP
INR	-0.17933	0.012769	0.078805	0.106029
ARR	0.012769	-0.05304	0.017974	0.039492
OVR	0.078805	0.017974	-0.03535	-0.0158
DEP	0.106029	0.039492	-0.0158	-0.05546

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

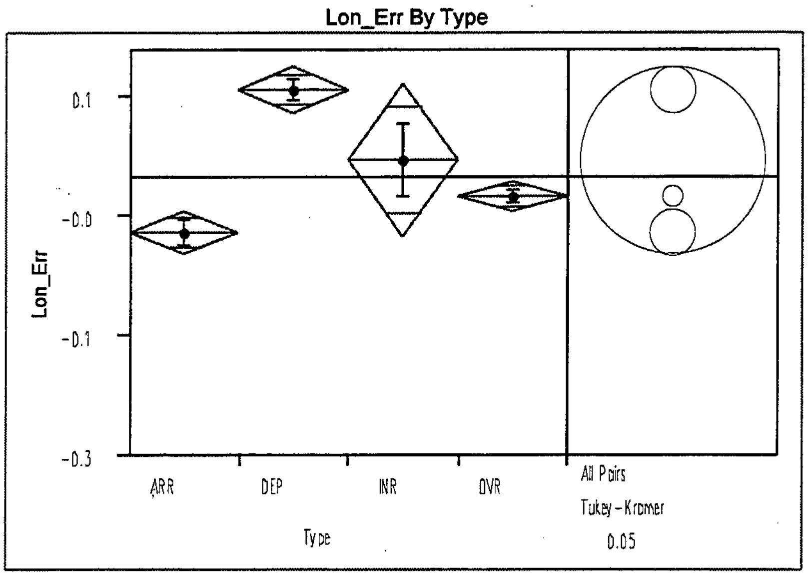
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	8448	1.612409	0.939075	0.938874
DEP	7726	1.250601	0.915938	0.914665
INR	739	1.764038	1.120226	1.119173
OVR	19015	1.220712	0.813887	0.813112

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	44.6490	3	35924	<.0001
Brown-Forsythe	52.2906	3	35924	<.0001
Levene	52.3370	3	35924	<.0001
Bartlett	391.0798	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
9.1155	3	3346.5	<.0001

Figure A.1- 58 Statistical Tests for Lateral Error and Flight Type at Look Ahead 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	8448	-0.06119	1.02906	0.01120
DEP	7726	0.059377	0.86403	0.00983
INR	739	-0.00021	0.86989	0.03200
OVR	19015	-0.02707	0.86590	0.00628

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.000000	0.059585	0.086450	0.120567
INR	-0.05959	0.000000	0.026864	0.060982
OVR	-0.08645	-0.02686	0.000000	0.034117
ARR	-0.12057	-0.06098	-0.03412	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56915

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-0.03748	-0.0301	0.055025	0.083901
INR	-0.0301	-0.12117	-0.06047	-0.02837
OVR	0.055025	-0.06047	-0.02389	0.003663
ARR	0.083901	-0.02837	0.003663	-0.03584

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	8448	1.029061	0.6658010	0.6657831
DEP	7726	0.864030	0.5779702	0.5778819
INR	739	0.869889	0.5829329	0.5829153
OVR	19015	0.865901	0.5939413	0.5938627

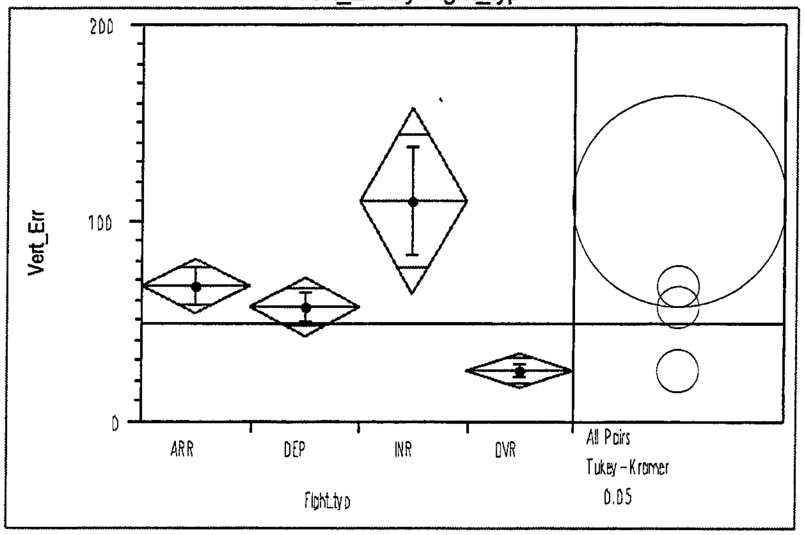
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	5.5325	3	35924	0.0009
Brown-Forsythe	29.0760	3	35924	<.0001
Levene	29.0404	3	35924	<.0001
Bartlett	136.8188	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
25.9604	3	3418.8	<.0001

Figure A.1- 59 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 0 for Samples at All Altitudes

Vert_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	8448	70.188	925.088	10.065
DEP	7726	61.550	660.830	7.518
INR	739	121.234	758.396	27.898
OVR	19015	32.353	499.734	3.624

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.0000	51.0458	59.6838	88.8804
ARR	-51.0458	0.0000	8.6380	37.8346
DEP	-59.6838	-8.6380	0.0000	29.1965
OVR	-88.8804	-37.8346	-29.1965	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56915

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-88.5683	-14.2632	-5.8702	25.0478
ARR	-14.2632	-26.1953	-18.1623	15.5741
DEP	-5.8702	-18.1623	-27.3920	6.2272
OVR	25.0478	15.5741	6.2272	-17.4603

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	8448	925.0881	399.3161	373.8933
DEP	7726	660.8301	279.6681	261.3665
INR	739	758.3961	353.6892	328.3434
OVR	19015	499.7343	122.1939	100.6145

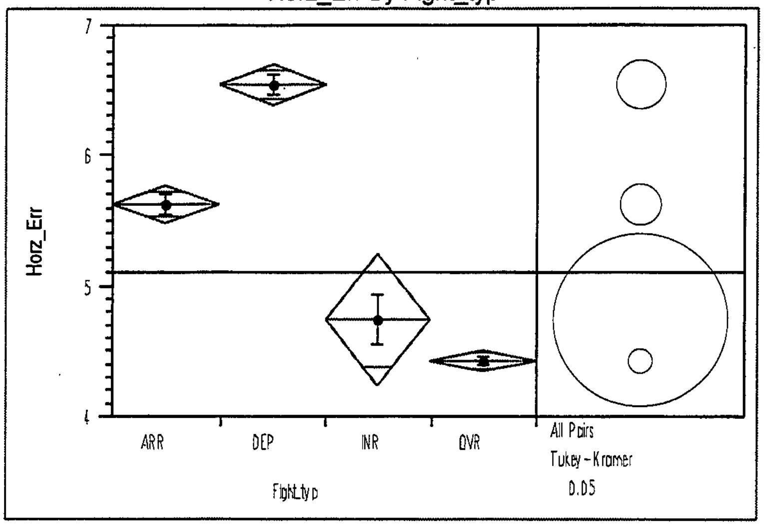
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.2275	3	35924	0.0003
Brown-Forsythe	417.0248	3	35924	<.0001
Levene	438.9741	3	35924	<.0001
Bartlett	1646.0411	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
9.9148	3	3305.4	<.0001

Figure A.1- 60 Statistical Tests for Vertical Error and Flight Type at Look Ahead 0 for Samples at All Altitudes

Horz_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5424	5.65443	5.82123	0.07904
DEP	4416	6.54882	5.94563	0.08947
INR	420	4.76544	4.14447	0.20223
OVR	13704	4.43793	5.06903	0.04330

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	INR	OVR
DEP	0.00000	0.89439	1.78339	2.11089
ARR	-0.89439	0.00000	0.88900	1.21651
INR	-1.78339	-0.88900	0.00000	0.32751
OVR	-2.11089	-1.21651	-0.32751	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56921

Abs(Dif)-LSD	DEP	ARR	INR	OVR
DEP	-0.29535	0.61309	1.07472	1.87075
ARR	0.61309	-0.26650	0.18607	0.99387
INR	1.07472	0.18607	-0.95770	-0.35999
OVR	1.87075	0.99387	-0.35999	-0.16766

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5424	5.821235	3.814676	3.577853
DEP	4416	5.945632	4.499082	4.253545
INR	420	4.144473	3.068972	2.938459
OVR	13704	5.069030	3.194342	2.906630

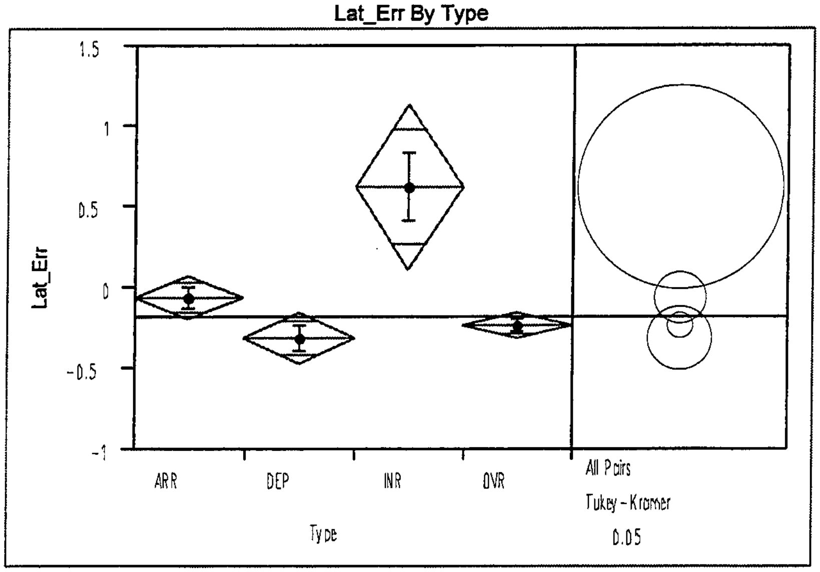
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.9006	3	23960	0.0021
Brown-Forsythe	107.3528	3	23960	<.0001
Levene	127.4396	3	23960	<.0001
Bartlett	102.1086	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
179.2093	3	1964.4	<.0001

Figure A.1- 61 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 600 for Samples at All Altitudes

Lat_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5424	-0.04855	5.18728	0.07043
DEP	4416	-0.29545	5.74566	0.08646
INR	420	0.639414	4.31964	0.21078
OVR	13704	-0.204	5.45218	0.04657

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	OVR	DEP
INR	0.000000	0.687965	0.843415	0.934862
ARR	-0.68796	0.000000	0.155450	0.246898
OVR	-0.84342	-0.15545	0.000000	0.091447
DEP	-0.93486	-0.2469	-0.09145	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56921

Abs(Dif)-LSD	INR	ARR	OVR	DEP
INR	-0.96295	-0.01882	0.152151	0.222308
ARR	-0.01882	-0.26796	-0.0684	-0.03594
OVR	0.152151	-0.0684	-0.16858	-0.15002
DEP	0.222308	-0.03594	-0.15002	-0.29697

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5424	5.187277	2.768101	2.765340
DEP	4416	5.745658	3.188760	3.155276
INR	420	4.319640	2.608779	2.566873
OVR	13704	5.452177	2.840231	2.817599

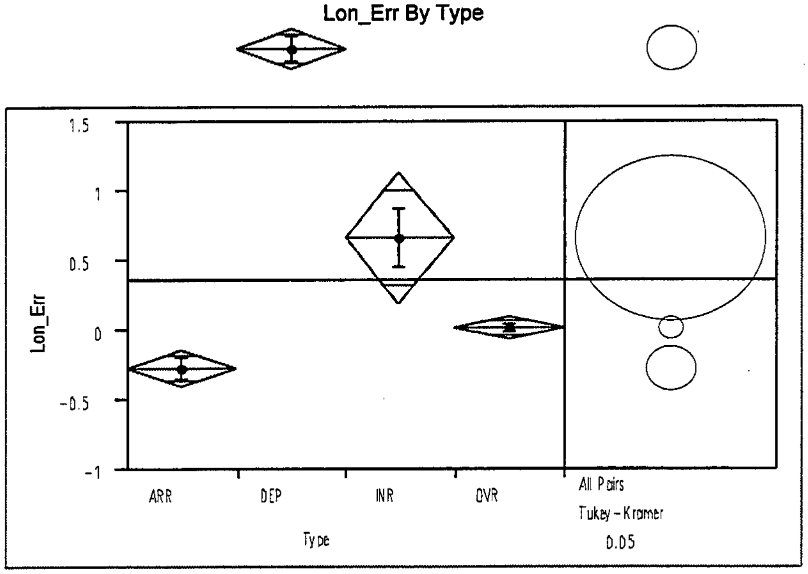
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.5416	3	23960	0.0545
Brown-Forsythe	7.7254	3	23960	<.0001
Levene	8.5242	3	23960	<.0001
Bartlett	29.8614	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.7387	3	1972.8	0.0002

Figure A.1- 62 Statistical Tests for Lateral Error and Flight Type at Look Ahead 600 for Samples at All Altitudes

Lon_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5424	-0.25745	6.23609	0.08467
DEP	4416	2.04462	6.40047	0.09632
INR	420	0.67902	4.51763	0.22044
OVR	13704	0.05435	3.95233	0.03376

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.00000	1.36560	1.99028	2.30208
INR	-1.36560	0.00000	0.62467	0.93647
OVR	-1.99028	-0.62467	0.00000	0.31180
ARR	-2.30208	-0.93647	-0.31180	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56921

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-0.27687	0.70129	1.76516	2.03839
INR	0.70129	-0.89776	-0.01979	0.27754
OVR	1.76516	-0.01979	-0.15717	0.10310
ARR	2.03839	0.27754	0.10310	-0.24982

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

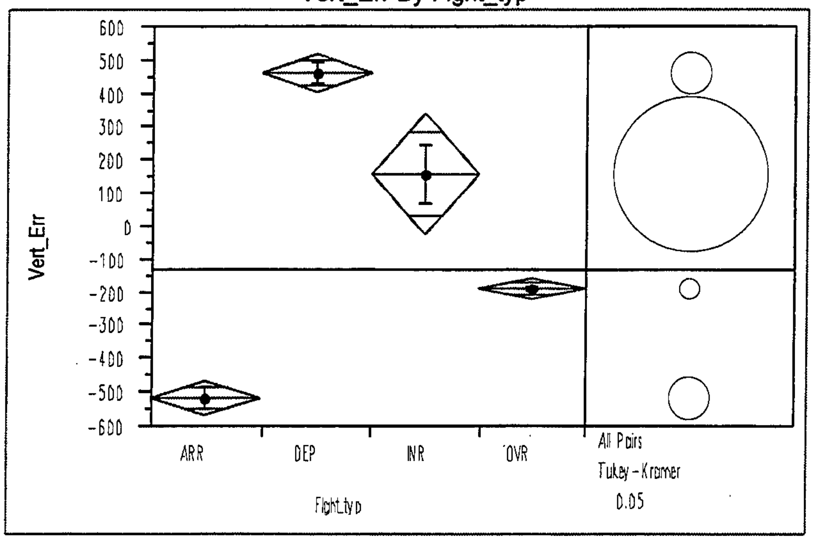
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5424	6.236088	4.083972	4.070124
DEP	4416	6.400468	4.679750	4.616607
INR	420	4.517630	3.223334	3.200056
OVR	13704	3.952328	2.541685	2.541273

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	59.7962	3	23960	<.0001
Brown-Forsythe	438.6663	3	23960	<.0001
Levene	468.8180	3	23960	<.0001
Bartlett	852.8624	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
139.5878	3	1898.5	<.0001

Figure A.1- 63 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5424	-508.568	2752.91	37.379
DEP	4416	473.214	2422.84	36.459
INR	420	169.747	1934.90	94.413
OVR	13704	-177.748	1241.07	10.602

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.000	303.467	650.962	981.782
INR	-303.467	0.000	347.495	678.315
OVR	-650.962	-347.495	0.000	330.820
ARR	-981.782	-678.315	-330.820	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56921

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-105.786	49.644	564.948	881.030
INR	49.644	-343.019	101.255	426.548
OVR	564.948	101.255	-60.051	251.079
ARR	881.030	426.548	251.079	-95.452

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5424	2752.906	1885.542	1826.528
DEP	4416	2422.842	1473.997	1279.100
INR	420	1934.898	1129.098	1087.200
OVR	13704	1241.074	558.379	436.680

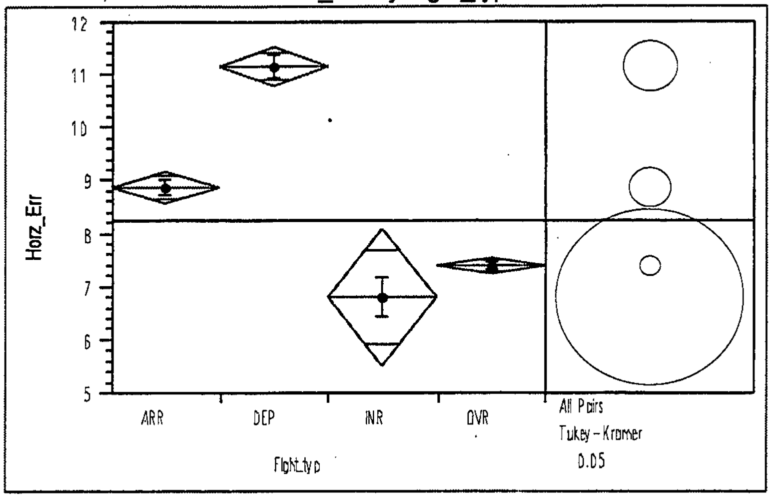
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	288.9470	3	23960	<.0001
Brown-Forsythe	1026.7023	3	23960	0.0000
Levene	1125.4173	3	23960	0.0000
Bartlett	2118.3415	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
134.0774	3	1856.9	<.0001

Figure A.1- 64 Statistical Tests for Vertical Error and Flight Type at Look Ahead 600 for Samples at All Altitudes

Horz_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2752	8.8888	8.6910	0.16567
DEP	2023	11.1970	10.5830	0.23529
INR	175	6.8506	4.9372	0.37322
OVR	8886	7.4045	8.4128	0.08925

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.00000	2.30816	3.79246	4.34642
ARR	-2.30816	0.00000	1.48430	2.03826
OVR	-3.79246	-1.48430	0.00000	0.55396
INR	-4.34642	-2.03826	-0.55396	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56934

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-0.70965	1.64717	3.23647	2.56804
ARR	1.64717	-0.60844	0.99193	0.27873
OVR	3.23647	0.99193	-0.33860	-1.16887
INR	2.56804	0.27873	-1.16887	-2.41282

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

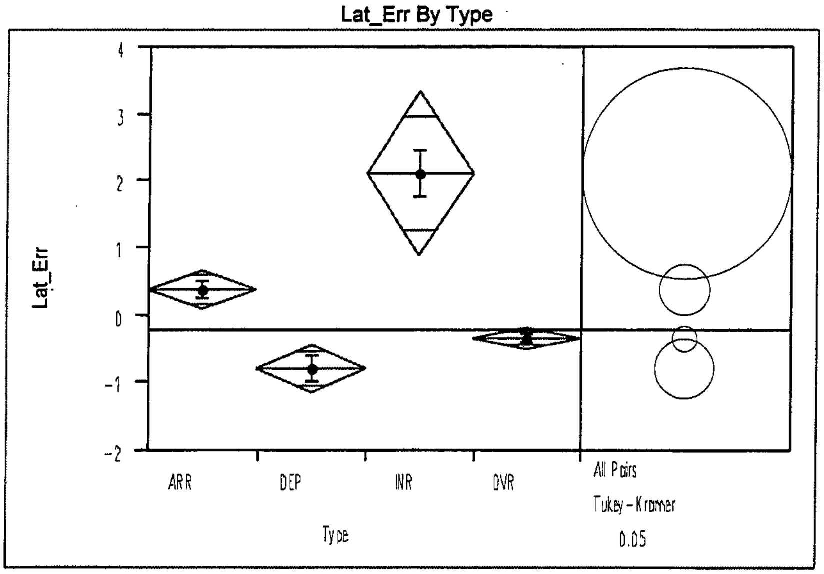
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2752	8.69101	6.045259	5.670412
DEP	2023	10.58296	7.855500	7.408243
INR	175	4.93723	4.010688	3.978116
OVR	8886	8.41275	5.165765	4.768198

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.2481	3	13832	0.0052
Brown-Forsythe	74.8990	3	13832	<.0001
Levene	97.7130	3	13832	<.0001
Bartlett	91.2170	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
88.9024	3	838	<.0001

Figure A.1- 65 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2752	0.44933	6.90750	0.13167
DEP	2023	-0.77607	9.65818	0.21473
INR	175	2.13575	4.82428	0.36468
OVR	8886	-0.33598	8.55880	0.09079

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	OVR	DEP
INR	0.00000	1.68642	2.47173	2.91182
ARR	-1.68642	0.00000	0.78532	1.22540
OVR	-2.47173	-0.78532	0.00000	0.44008
DEP	-2.91182	-1.22540	-0.44008	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56934

Abs(Dif)-LSD	INR	ARR	OVR	DEP
INR	-2.30583	0.00491	0.82529	1.21229
ARR	0.00491	-0.58146	0.31478	0.59372
OVR	0.82529	0.31478	-0.32359	-0.09126
DEP	1.21229	0.59372	-0.09126	-0.67819

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

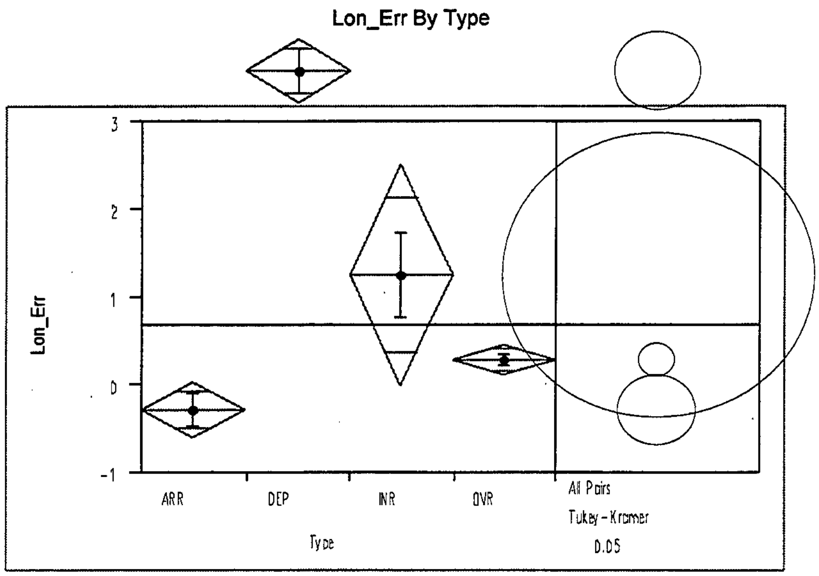
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2752	6.907495	3.510546	3.454990
DEP	2023	9.658175	5.029599	4.861608
INR	175	4.824283	3.566948	3.217192
OVR	8886	8.558796	4.282437	4.228983

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	5.9916	3	13832	0.0004
Brown-Forsythe	16.0369	3	13832	<.0001
Levene	17.9417	3	13832	<.0001
Bartlett	118.2192	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
23.8050	3	840.91	<.0001

Figure A.1- 66 Statistical Tests for Lateral Error and Flight Type at Look Ahead 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2752	-0.23783	10.3248	0.19681
DEP	2023	3.56685	11.4377	0.25430
INR	175	1.29445	6.4830	0.49007
OVR	8886	0.31763	7.2209	0.07660

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.00000	2.27240	3.24922	3.80467
INR	-2.27240	0.00000	0.97682	1.53227
OVR	-3.24922	-0.97682	0.00000	0.55546
ARR	-3.80467	-1.53227	-0.55546	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56934

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-0.69658	0.52678	2.70347	3.15586
INR	0.52678	-2.36837	-0.71429	-0.19485
OVR	2.70347	-0.71429	-0.33237	0.07216
ARR	3.15586	-0.19485	0.07216	-0.59723

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

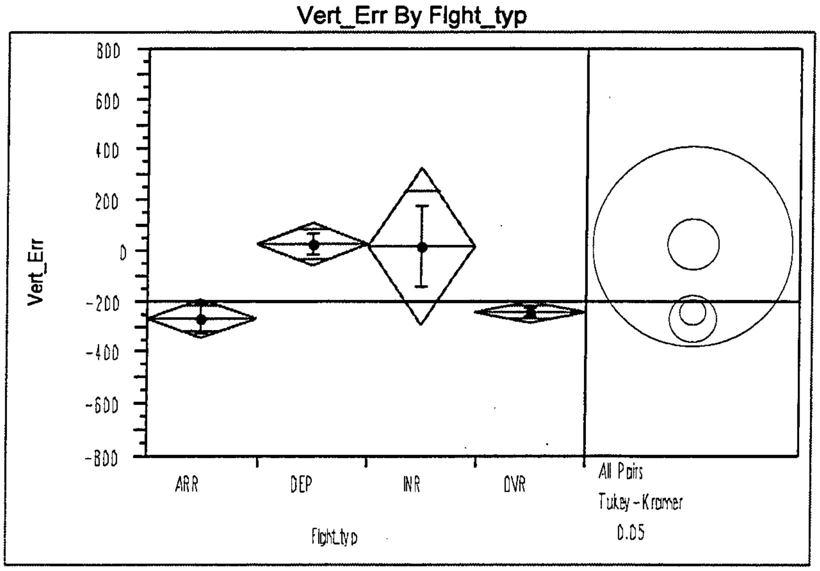
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2752	10.32481	7.077953	7.042463
DEP	2023	11.43775	8.120808	8.061091
INR	175	6.48303	5.234365	5.063142
OVR	8886	7.22086	4.702144	4.701919

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	46.8839	3	13832	<.0001
Brown-Forsythe	205.5680	3	13832	<.0001
Levene	215.3588	3	13832	<.0001
Bartlett	372.2710	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
55.8382	3	801.21	<.0001

Figure A.1- 67 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2752	-266.505	3142.50	59.90
DEP	2023	32.538	1905.68	42.37
INR	175	19.197	2148.85	162.44
OVR	8886	-237.760	1722.27	18.27

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.000	13.341	270.298	299.042
INR	-13.341	0.000	256.957	285.701
OVR	-270.298	-256.957	0.000	28.745
ARR	-299.042	-285.701	-28.745	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56934

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-170.580	-414.131	136.653	140.160
INR	-414.131	-579.972	-157.164	-137.239
OVR	136.653	-157.164	-81.390	-89.607
ARR	140.160	-137.239	-89.607	-146.252

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2752	3142.501	2192.247	2172.187
DEP	2023	1905.676	926.247	913.391
INR	175	2148.850	1385.400	1384.143
OVR	8886	1722.271	784.667	633.630

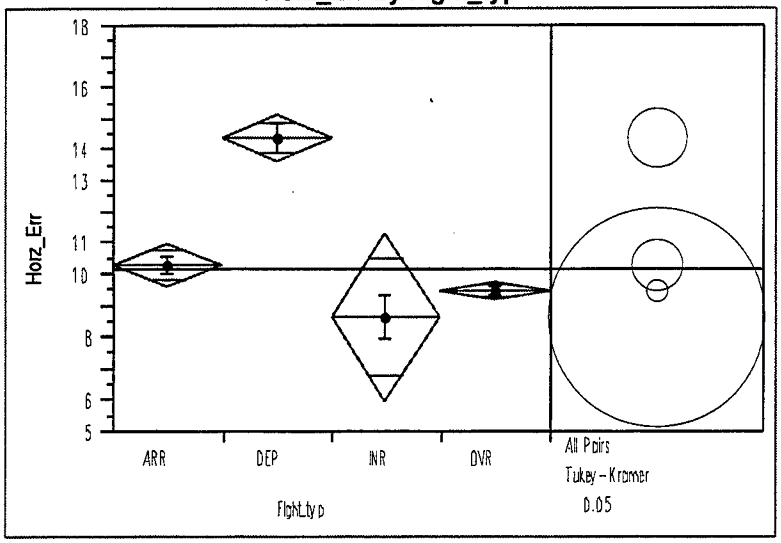
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	54.8177	3	13832	<.0001
Brown-Forsythe	527.8600	3	13832	0.0000
Levene	478.1322	3	13832	<.0001
Bartlett	613.3899	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
12.4580	3	791.61	<.0001

Figure A.1- 68 Statistical Tests for Vertical Error and Flight Type at Look Ahead 1200 for Samples at All Altitudes

Horz_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	923	10.2990	10.3021	0.33910
DEP	774	14.3842	13.9167	0.50022
INR	61	8.6425	5.6802	0.72728
OVR	4686	9.4641	10.3259	0.15084

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.00000	4.08526	4.92009	5.74179
ARR	-4.08526	0.00000	0.83483	1.65653
OVR	-4.92009	-0.83483	0.00000	0.82170
INR	-5.74179	-1.65653	-0.82170	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56970

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-1.40875	2.73456	3.84483	2.05627
ARR	2.73456	-1.29004	-0.16317	-2.00719
OVR	3.84483	-0.16317	-0.57254	-2.74966
INR	2.05627	-2.00719	-2.74966	-5.01811

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

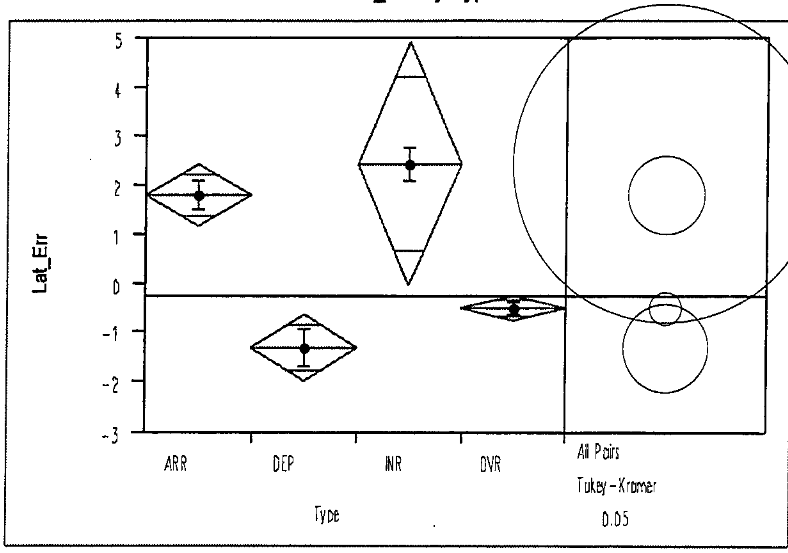
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	923	10.30205	7.13410	6.576544
DEP	774	13.91667	10.19334	9.676541
INR	61	5.68024	4.97916	4.921205
OVR	4686	10.32587	6.34870	5.914651

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.8899	3	6440	0.0021
Brown-Forsythe	38.7993	3	6440	<.0001
Levene	50.2465	3	6440	<.0001
Bartlett	58.0560	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
30.8836	3	285.23	<.0001

Figure A.1- 69 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	923	1.84524	9.3618	0.30815
DEP	774	-1.31193	10.6583	0.38310
INR	61	2.45212	2.8399	0.36361
OVR	4686	-0.48365	10.0897	0.14739

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	OVR	DEP
INR	0.00000	0.60688	2.93577	3.76405
ARR	-0.60688	0.00000	2.32889	3.15717
OVR	-2.93577	-2.32889	0.00000	0.82828
DEP	-3.76405	-3.15717	-0.82828	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56970

Abs(Dif)-LSD	INR	ARR	OVR	DEP
INR	-4.66040	-2.79567	-0.38101	0.34126
ARR	-2.79567	-1.19808	1.40203	1.90275
OVR	-0.38101	1.40203	-0.53172	-0.17033
DEP	0.34126	1.90275	-0.17033	-1.30833

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	923	9.36175	5.056806	4.601354
DEP	774	10.65830	5.646032	5.238998
INR	61	2.83989	2.358812	2.014416
OVR	4686	10.08974	4.814552	4.715546

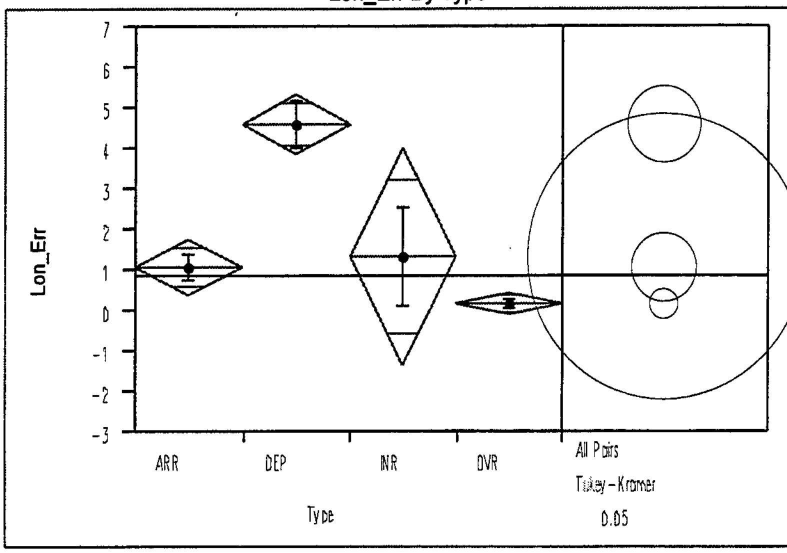
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.7704	3	6440	0.5104
Brown-Forsythe	2.8275	3	6440	0.0371
Levene	3.8527	3	6440	0.0091
Bartlett	36.8738	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
34.2560	3	329.56	<.0001

Figure A.1- 70 Statistical Tests for Lateral Error and Flight Type at Look Ahead 1800 for Samples at All Altitudes

Lon_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	923	1.08070	10.9588	0.3607
DEP	774	4.62673	16.2509	0.5841
INR	61	1.35041	9.6005	1.2292
OVR	4686	0.20939	9.7022	0.1417

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	ARR	OVR
DEP	0.00000	3.27632	3.54602	4.41734
INR	-3.27632	0.00000	0.26970	1.14102
ARR	-3.54602	-0.26970	0.00000	0.87132
OVR	-4.41734	-1.14102	-0.87132	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56970

Abs(Dif)-LSD	DEP	INR	ARR	OVR
DEP	-1.42034	-0.43952	2.18420	3.33323
INR	-0.43952	-5.05940	-3.42416	-2.45973
ARR	2.18420	-3.42416	-1.30066	-0.13490
OVR	3.33323	-2.45973	-0.13490	-0.57725

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	923	10.95884	7.66131	7.65645
DEP	774	16.25086	11.28068	11.26191
INR	61	9.60051	7.87813	7.78761
OVR	4686	9.70217	6.60987	6.60351

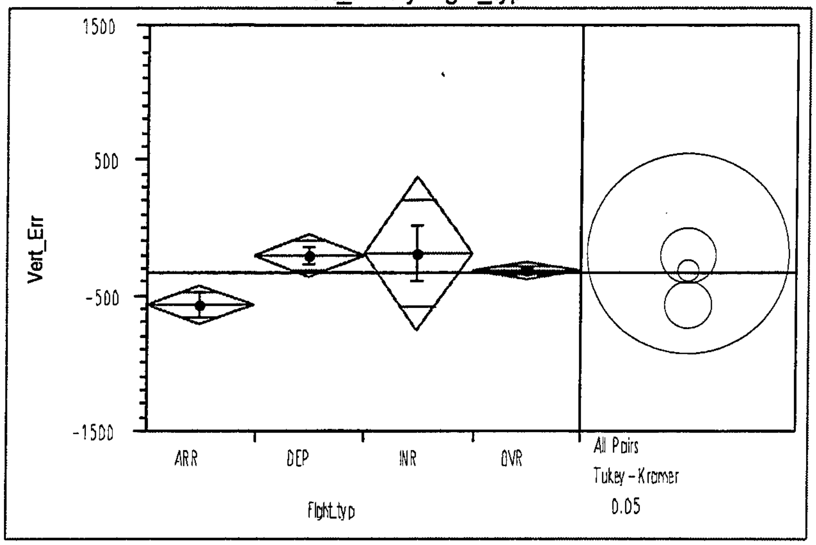
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	47.5172	3	6440	<.0001
Brown-Forsythe	77.6498	3	6440	<.0001
Levene	78.4720	3	6440	<.0001
Bartlett	148.7540	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
18.9311	3	272.99	<.0001

Figure A.1- 71 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 1800 for Samples at All Altitudes

Vert_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	923	-554.826	3315.83	109.14
DEP	774	-193.895	1909.90	68.65
INR	61	-182.768	1606.16	205.65
OVR	4686	-306.194	2109.86	30.82

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.000	11.127	123.426	372.058
DEP	-11.127	0.000	112.299	360.931
OVR	-123.426	-112.299	0.000	248.632
ARR	-372.058	-360.931	-248.632	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*

2.56970

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-1068.61	-773.70	-637.09	-408.13
DEP	-773.70	-299.99	-116.68	73.30
OVR	-637.09	-116.68	-121.92	36.11
ARR	-408.13	73.30	36.11	-274.71

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	923	3315.832	2390.947	2384.889
DEP	774	1909.896	982.823	867.364
INR	61	1606.156	1124.436	1093.585
OVR	4686	2109.856	1060.170	882.069

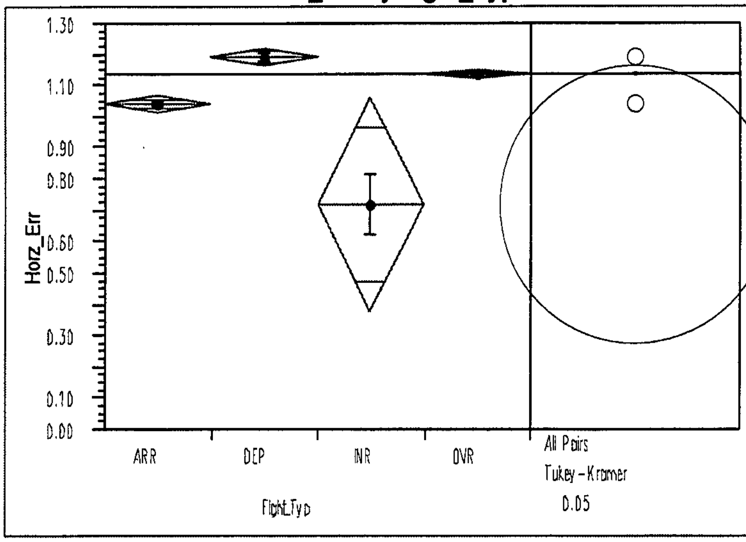
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	14.8573	3	6440	<.0001
Brown-Forsythe	153.9664	3	6440	<.0001
Levene	135.4751	3	6440	<.0001
Bartlett	148.1365	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.7205	3	277.94	0.0448

Figure A.1- 72 Statistical Tests for Vertical Error and Flight Type at Look Ahead 1800 for Samples at All Altitudes

Horz_Err By Flght_Typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	4349	1.04608	0.779149	0.01181
DEP	3954	1.19398	0.951797	0.01514
INR	28	0.72009	0.526729	0.09954
OVR	17817	1.14703	0.975480	0.00731

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	ARR	INR
DEP	0.000000	0.046943	0.147892	0.473892
OVR	-0.04694	0.000000	0.100950	0.426949
ARR	-0.14789	-0.10095	0.000000	0.325999
INR	-0.47389	-0.42695	-0.326	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56920

Abs(Dif)-LSD	DEP	OVR	ARR	INR
DEP	-0.05441	0.004414	0.094733	0.015082
OVR	0.004414	-0.02563	0.060032	-0.0306
ARR	0.094733	0.060032	-0.05188	-0.13266
INR	0.015082	-0.0306	-0.13266	-0.64657

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	4349	0.7791494	0.6031522	0.5858818
DEP	3954	0.9517968	0.6777382	0.6582575
INR	28	0.5267289	0.4490194	0.4421643
OVR	17817	0.9754801	0.6561249	0.6345357

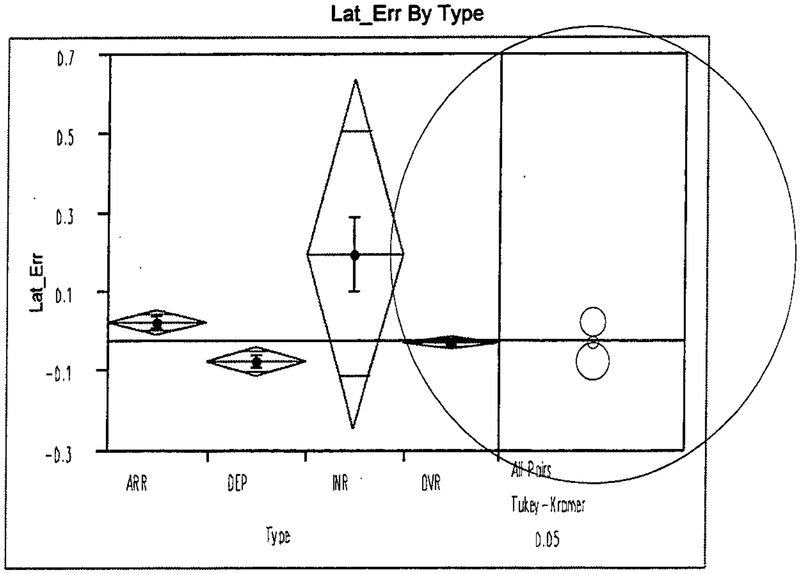
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.0137	3	26144	0.3853
Brown-Forsythe	8.1709	3	26144	<.0001
Levene	10.3530	3	26144	<.0001
Bartlett	111.3007	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
29.9164	3	134.7	<.0001

Figure A.1- 73 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 0 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	4349	0.023929	1.08964	0.01652
DEP	3954	-0.07542	1.20787	0.01921
INR	28	0.202157	0.52083	0.09843
OVR	17817	-0.02599	1.22300	0.00916

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	OVR	DEP
INR	0.000000	0.178228	0.228142	0.277578
ARR	-0.17823	0.000000	0.049914	0.099349
OVR	-0.22814	-0.04991	0.000000	0.049436
DEP	-0.27758	-0.09935	-0.04944	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56920

Abs(Dif)-LSD	INR	ARR	OVR	DEP
INR	-0.82329	-0.4058	-0.35447	-0.30663
ARR	-0.4058	-0.06606	-0.00219	0.031660
OVR	-0.35447	-0.00219	-0.03264	-0.00472
DEP	-0.30663	0.031660	-0.00472	-0.06928

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

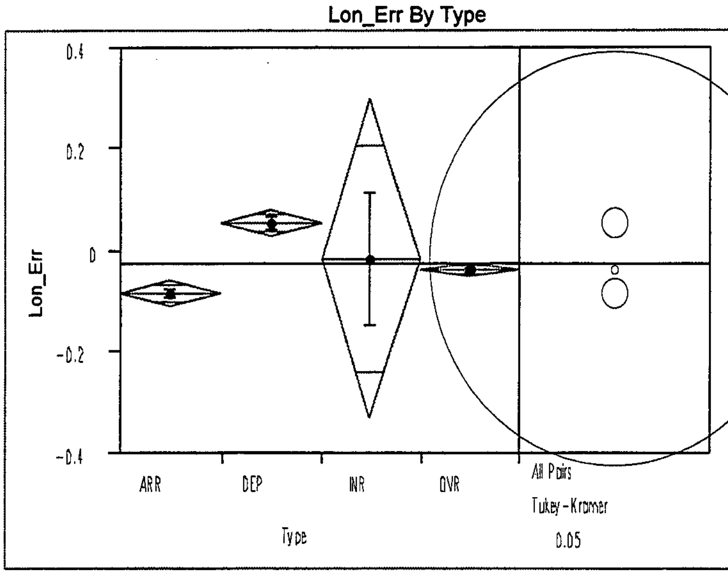
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	4349	1.089636	0.7363338	0.7355038
DEP	3954	1.207866	0.8603305	0.8572336
INR	28	0.520833	0.3176684	0.3121000
OVR	17817	1.222998	0.8094429	0.8089403

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.2692	3	26144	0.0783
Brown-Forsythe	16.3464	3	26144	<.0001
Levene	16.7351	3	26144	<.0001
Bartlett	37.3253	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.8777	3	135.28	0.0002

Figure A.1- 74 Statistical Tests for Lateral Error and Flight Type at Look Ahead 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	4349	-0.07945	0.712339	0.01080
DEP	3954	0.064564	0.929010	0.01477
INR	28	-0.00764	0.708145	0.13383
OVR	17817	-0.03093	0.877478	0.00657

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.000000	0.072203	0.095493	0.144011
INR	-0.0722	0.000000	0.023290	0.071808
OVR	-0.09549	-0.02329	0.000000	0.048519
ARR	-0.14401	-0.07181	-0.04852	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56920

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-0.04971	-0.34697	0.056638	0.095444
INR	-0.34697	-0.59072	-0.39474	-0.34723
OVR	0.056638	-0.39474	-0.02342	0.011136
ARR	0.095444	-0.34723	0.011136	-0.0474

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	4349	0.7123388	0.5450016	0.5447454
DEP	3954	0.9290096	0.6044064	0.6039326
INR	28	0.7081455	0.5404064	0.5390250
OVR	17817	0.8774782	0.5987171	0.5985922

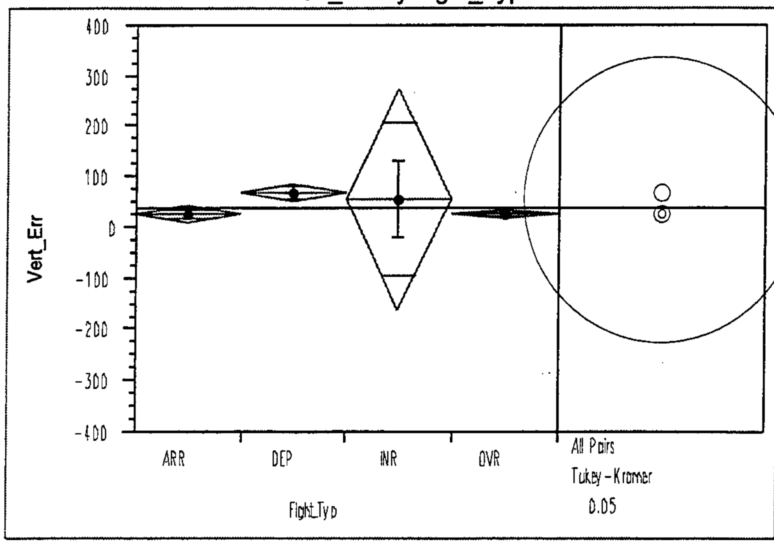
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.3048	3	26144	0.0747
Brown-Forsythe	9.4190	3	26144	<.0001
Levene	9.4162	3	26144	<.0001
Bartlett	112.6175	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
20.4530	3	134.2	<.0001

Figure A.1- 75 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 0 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Flght_Typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	4349	33.5672	678.371	10.287
DEP	3954	73.3885	796.740	12.671
INR	28	65.9412	408.616	77.221
OVR	17817	32.3289	510.259	3.823

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	ARR	OVR
DEP	0.0000	7.4473	39.8213	41.0596
INR	-7.4473	0.0000	32.3741	33.6123
ARR	-39.8213	-32.3741	0.0000	1.2383
OVR	-41.0596	-33.6123	-1.2383	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56920

Abs(Dif)-LSD	DEP	INR	ARR	OVR
DEP	-34.190	-280.860	6.417	14.335
INR	-280.860	-406.292	-255.841	-253.905
ARR	6.417	-255.841	-32.600	-24.474
OVR	14.335	-253.905	-24.474	-16.106

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

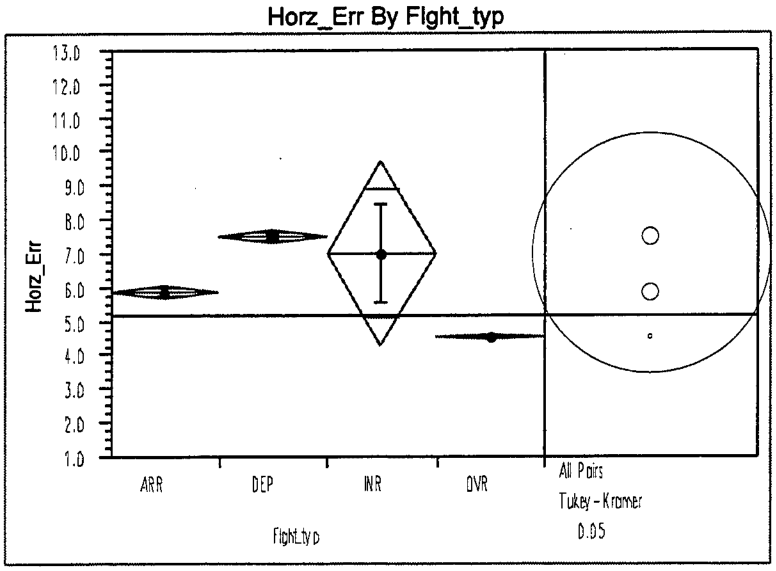
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	4349	678.3714	226.6330	210.8493
DEP	3954	796.7398	264.2650	232.0424
INR	28	408.6163	256.7743	226.6881
OVR	17817	510.2591	120.0023	97.5634

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.1109	3	26144	0.3432
Brown-Forsythe	88.3183	3	26144	<.0001
Levene	94.5199	3	26144	<.0001
Bartlett	582.8649	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.2411	3	134.08	0.0242

Figure A.1- 76 Statistical Tests for Vertical Error and Flight Type at Look Ahead 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2180	5.86620	6.69565	0.1434
DEP	3140	7.50980	6.31770	0.1127
INR	16	7.05297	6.02153	1.5054
OVR	12874	4.55009	5.17903	0.0456

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	ARR	OVR
DEP	0.00000	0.45684	1.64360	2.95971
INR	-0.45684	0.00000	1.18677	2.50287
ARR	-1.64360	-1.18677	0.00000	1.31610
OVR	-2.95971	-2.50287	-1.31610	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56927

Abs(Dif)-LSD	DEP	INR	ARR	OVR
DEP	-0.36244	-3.14254	1.24325	2.67388
INR	-3.14254	-5.07737	-2.41662	-1.08960
ARR	1.24325	-2.41662	-0.43498	0.98350
OVR	2.67388	-1.08960	0.98350	-0.17900

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2180	6.695652	4.365687	3.987987
DEP	3140	6.317700	4.868264	4.673344
INR	16	6.021531	5.056123	4.711769
OVR	12874	5.179030	3.279434	2.983894

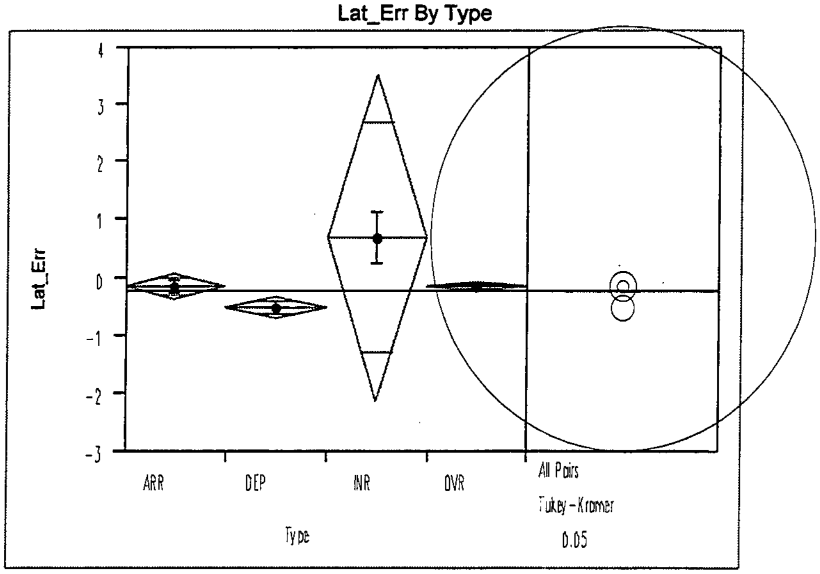
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	7.2002	3	18206	<.0001
Brown-Forsythe	122.4661	3	18206	<.0001
Levene	146.0102	3	18206	<.0001
Bartlett	134.2650	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
206.3231	3	74.401	<.0001

Figure A.1- 77 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 600 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2180	-0.16896	6.26443	0.13417
DEP	3140	-0.51797	6.36964	0.11367
INR	16	0.695931	1.85391	0.46348
OVR	12874	-0.17524	5.59431	0.04930

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	OVR	DEP
INR	0.00000	0.86490	0.87117	1.21390
ARR	-0.86490	0.00000	0.00628	0.34900
OVR	-0.87117	-0.00628	0.00000	0.34273
DEP	-1.21390	-0.34900	-0.34273	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56927

Abs(Dif)-LSD	INR	ARR	OVR	DEP
INR	-5.28294	-2.88439	-2.86675	-2.53121
ARR	-2.88439	-0.45259	-0.33979	-0.06756
OVR	-2.86675	-0.33979	-0.18624	0.04532
DEP	-2.53121	-0.06756	0.04532	-0.37711

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

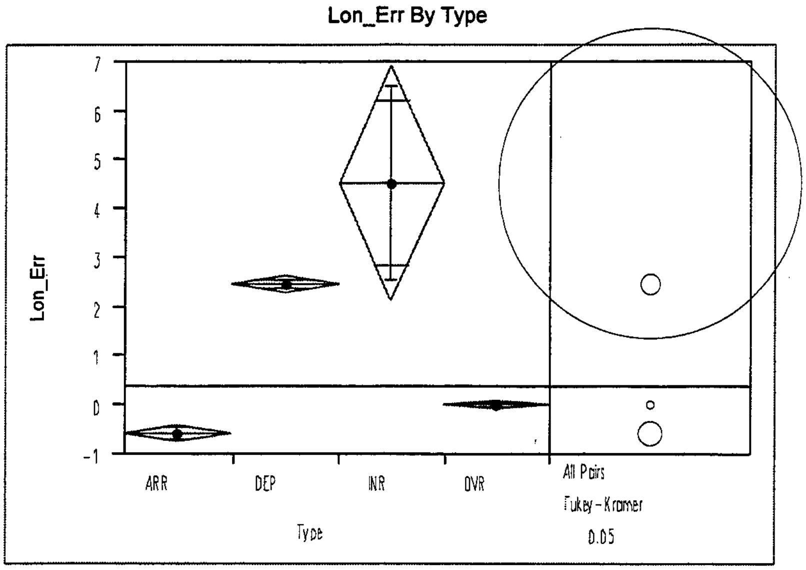
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2180	6.264428	3.285577	3.271467
DEP	3140	6.369638	3.649050	3.564355
INR	16	1.853908	1.125722	0.959294
OVR	12874	5.594305	2.920873	2.901661

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.3455	3	18206	0.0046
Brown-Forsythe	17.5723	3	18206	<.0001
Levene	20.5875	3	18206	<.0001
Bartlett	46.0556	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.8437	3	75.584	0.0128

Figure A.1- 78 Statistical Tests for Lateral Error and Flight Type at Look Ahead 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2180	-0.54771	6.29985	0.1349
DEP	3140	2.49767	7.01765	0.1252
INR	16	4.58689	7.93243	1.9831
OVR	12874	0.04333	4.02473	0.0355

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.00000	2.08922	4.54357	5.13460
DEP	-2.08922	0.00000	2.45435	3.04538
OVR	-4.54357	-2.45435	0.00000	0.59103
ARR	-5.13460	-3.04538	-0.59103	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56927

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-4.51878	-1.11417	1.34632	1.92764
DEP	-1.11417	-0.32256	2.19996	2.68907
OVR	1.34632	2.19996	-0.15930	0.29502
ARR	1.92764	2.68907	0.29502	-0.38713

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2180	6.299850	3.924904	3.888910
DEP	3140	7.017651	5.348000	5.294645
INR	16	7.932428	6.865618	6.553169
OVR	12874	4.024735	2.592419	2.592157

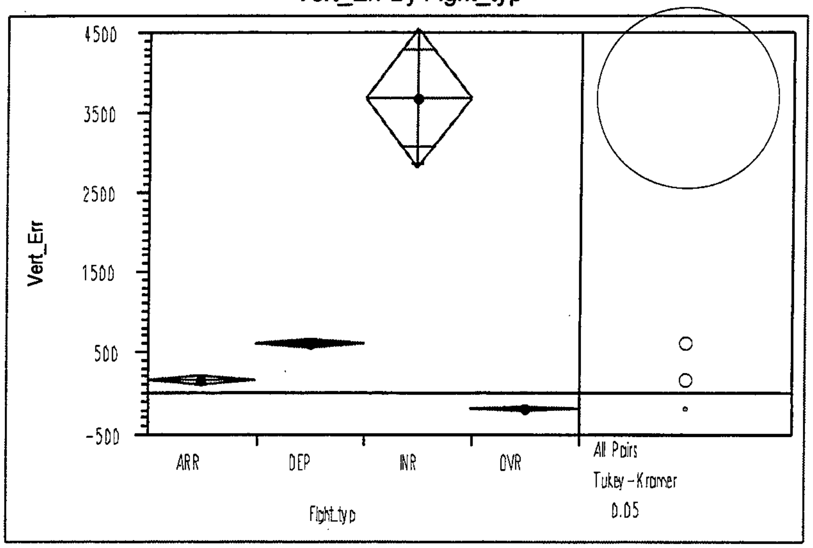
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	60.2987	3	18206	<.0001
Brown-Forsythe	487.4840	3	18206	<.0001
Levene	520.7569	3	18206	0.0000
Bartlett	744.9788	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
128.1541	3	74.281	<.0001

Figure A.1- 79 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 600 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	2180	175.38	2729.41	58.46
DEP	3140	627.24	2684.06	47.90
INR	16	3707.17	3264.89	816.22
OVR	12874	-168.77	1227.70	10.82

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.00	3079.93	3531.79	3875.94
DEP	-3079.93	0.00	451.86	796.01
ARR	-3531.79	-451.86	0.00	344.15
OVR	-3875.94	-796.01	-344.15	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56927

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-1627.04	1926.51	2377.09	2724.73
DEP	1926.51	-116.14	323.57	704.42
ARR	2377.09	323.57	-139.39	237.57
OVR	2724.73	704.42	237.57	-57.36

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

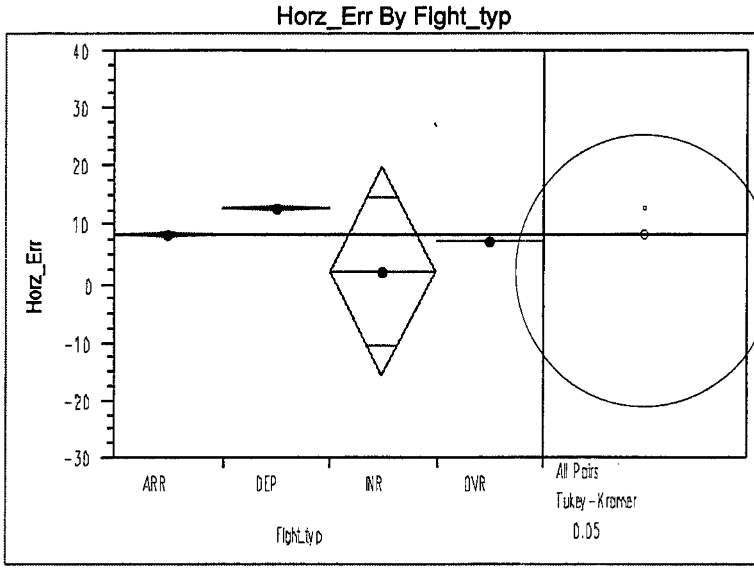
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	2180	2729.411	1761.558	1703.610
DEP	3140	2684.064	1748.244	1525.927
INR	16	3264.890	2778.220	2778.220
OVR	12874	1227.696	543.385	426.297

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	230.5318	3	18206	<.0001
Brown-Forsythe	728.5862	3	18206	0.0000
Levene	886.8506	3	18206	0.0000
Bartlett	1764.0818	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
101.9032	3	74.222	<.0001

Figure A.1- 80 Statistical Tests for Vertical Error and Flight Type at Look Ahead 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	729	8.7146	10.0791	0.37330
DEP	1365	13.4251	11.2510	0.30452
INR	1	2.4478	?	?
OVR	8279	7.6036	8.6140	0.09467

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.0000	4.7105	5.8215	10.9773
ARR	-4.7105	0.0000	1.1110	6.2668
OVR	-5.8215	-1.1110	0.0000	5.1558
INR	-10.9773	-6.2668	-5.1558	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56945

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-0.8961	3.6366	5.1376	-12.4419
ARR	3.6366	-1.2262	0.2066	-17.1599
OVR	5.1376	0.2066	-0.3639	-18.2563
INR	-12.4419	-17.1599	-18.2563	-33.1077

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	729	10.07914	6.567019	6.022739
DEP	1365	11.25095	8.540999	8.215322
INR	1	?	0.000000	0.000000
OVR	8279	8.61395	5.298427	4.889349

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	5.2489	2	10370	0.0053
Brown-Forsythe	112.7594	2	10370	<.0001
Levene	133.0604	2	10370	<.0001
Bartlett	103.2482	2	?	<.0001

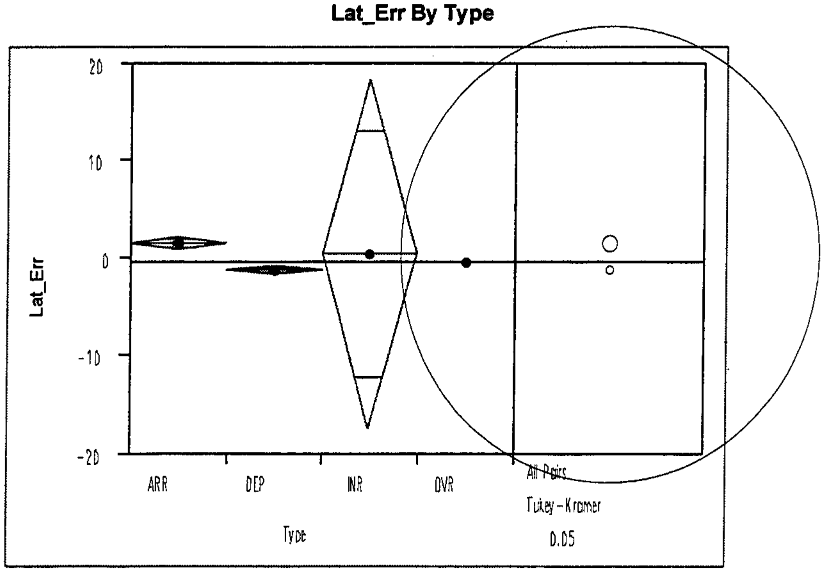
Warning: Small sample sizes. Use Caution.

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
167.7543	2	1446	<.0001

Figure A.1- 81 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 1200 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	729	1.56100	8.4561	0.31319
DEP	1365	-1.20794	11.3769	0.30793
INR	1	0.44280	?	?
OVR	8279	-0.27068	8.8052	0.09677

Means Comparisons

Dif=Mean[i]-Mean[j]	ARR	INR	OVR	DEP
ARR	0.00000	1.11820	1.83168	2.76894
INR	-1.11820	0.00000	0.71348	1.65074
OVR	-1.83168	-0.71348	0.00000	0.93726
DEP	-2.76894	-1.65074	-0.93726	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56945

Abs(Dif)-LSD	ARR	INR	OVR	DEP
ARR	-1.2330	-22.4383	0.9222	1.6891
INR	-22.4383	-33.2911	-22.8283	-21.8982
OVR	0.9222	-22.8283	-0.3659	0.2496
DEP	1.6891	-21.8982	0.2496	-0.9011

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	729	8.45614	4.767762	4.416341
DEP	1365	11.37686	6.363812	6.059668
INR	1	?	0.000000	0.000000
OVR	8279	8.80522	4.409537	4.367785

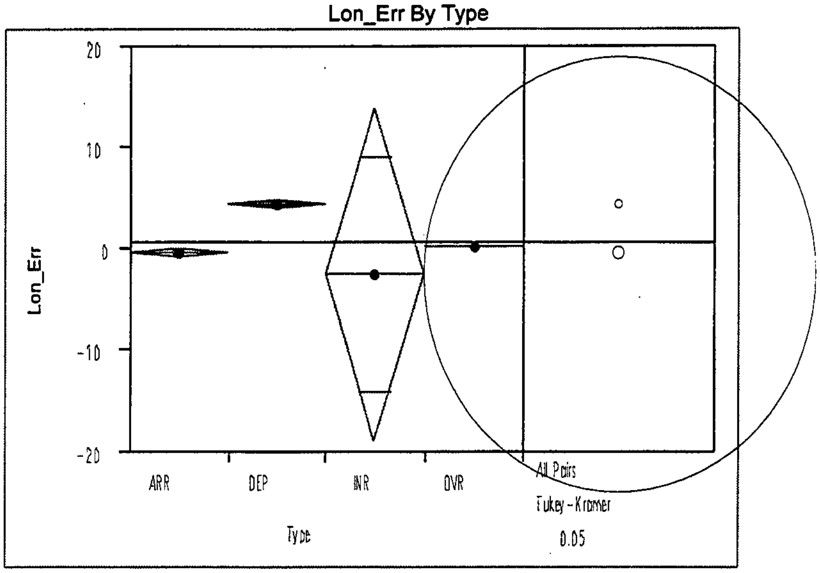
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	7.8126	2	10370	0.0004
Brown-Forsythe	26.8696	2	10370	<.0001
Levene	36.4313	2	10370	<.0001
Bartlett	91.3932	2	?	<.0001

Warning: Small sample sizes. Use Caution.

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
21.4219	2	1495.7	<.0001

Figure A.1- 82 Statistical Tests for Lateral Error and Flight Type at Look Ahead 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	729	-0.38947	10.1754	0.37687
DEP	1365	4.47971	12.4889	0.33803
INR	1	-2.40740	?	?
OVR	8279	0.29626	7.3708	0.08101

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	ARR	INR
DEP	0.00000	4.18344	4.86918	6.88711
OVR	-4.18344	0.00000	0.68573	2.70366
ARR	-4.86918	-0.68573	0.00000	2.01793
INR	-6.88711	-2.70366	-2.01793	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56945

Abs(Dif)-LSD	DEP	OVR	ARR	INR
DEP	-0.8296	3.5503	3.8749	-14.7947
OVR	3.5503	-0.3369	-0.1516	-18.9715
ARR	3.8749	-0.1516	-1.1352	-19.6708
INR	-14.7947	-18.9715	-19.6708	-30.6515

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	729	10.17541	6.081124	6.059737
DEP	1365	12.48892	9.400217	9.368357
INR	1	?	0.000000	0.000000
OVR	8279	7.37080	4.808462	4.808404

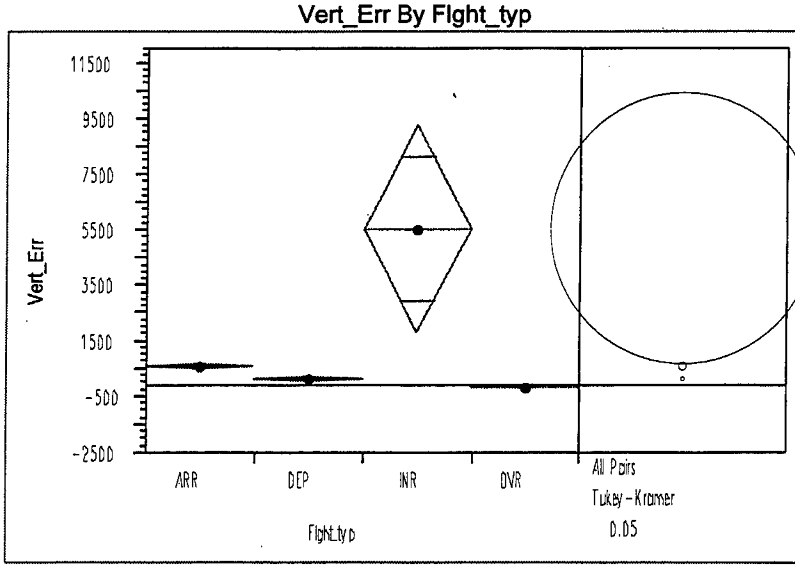
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	57.1117	2	10370	<.0001
Brown-Forsythe	317.8020	2	10370	<.0001
Levene	324.5898	2	10370	<.0001
Bartlett	444.6502	2	?	<.0001

Warning: Small sample sizes. Use Caution.

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
75.1969	2	1388.2	<.0001

Figure A.1- 83 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	729	579.37	3291.49	121.91
DEP	1365	104.24	2134.86	57.78
INR	1	5507.95	?	?
OVR	8279	-198.02	1698.40	18.67

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.00	4928.58	5403.71	5705.97
ARR	-4928.58	0.00	475.12	777.39
DEP	-5403.71	-475.12	0.00	302.26
OVR	-5705.97	-777.39	-302.26	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56945

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-6954.32	7.76	484.46	788.23
ARR	7.76	-257.57	249.54	587.41
DEP	484.46	249.54	-188.23	158.61
OVR	788.23	587.41	158.61	-76.43

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	729	3291.494	2276.198	2138.758
DEP	1365	2134.857	1136.639	1086.583
INR	1	?	0.000	0.000
OVR	8279	1698.399	733.179	605.093

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	29.8563	2	10370	<.0001
Brown-Forsythe	292.7935	2	10370	<.0001
Levene	312.5342	2	10370	<.0001
Bartlett	444.4994	2	?	<.0001

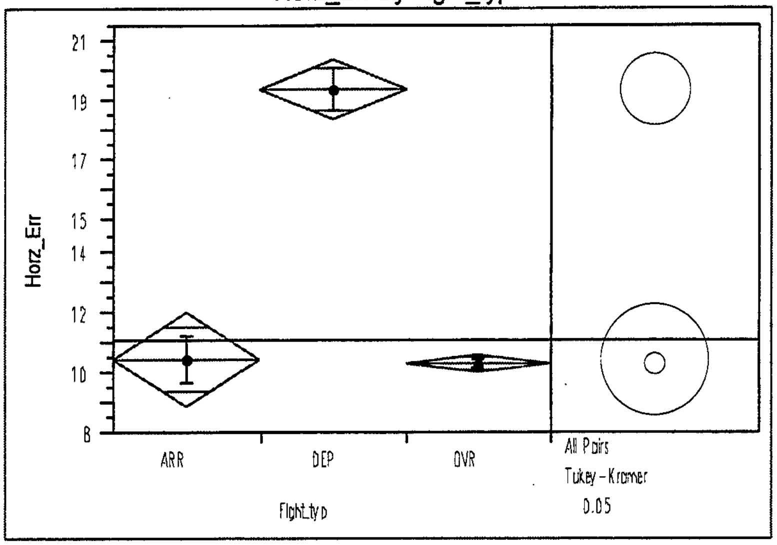
Warning: Small sample sizes. Use Caution.

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
30.8476	2	1387.2	<.0001

Figure A.1- 84 Statistical Tests for Vertical Error and Flight Type at Look Ahead 1200 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Flght_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	192	9.8864	11.3504	0.81914
DEP	453	18.8873	15.5140	0.72891
OVR	4246	9.7690	10.6856	0.16399

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR
DEP	0.00000	9.00087	9.11827
ARR	-9.00087	0.00000	0.11739
OVR	-9.11827	-0.11739	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	DEP	ARR	OVR
DEP	-1.75171	6.73060	7.81522
ARR	6.73060	-2.69068	-1.82775
OVR	7.81522	-1.82775	-0.57217

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

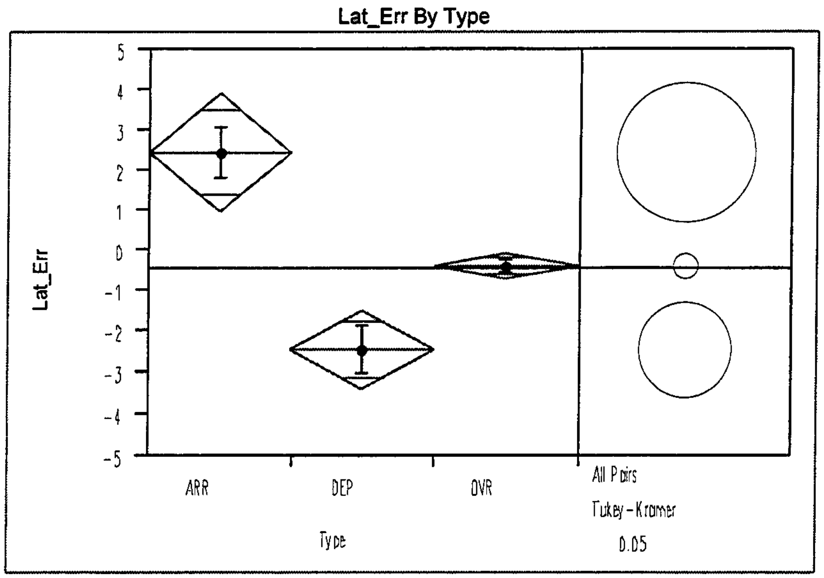
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	192	11.35035	7.21880	6.58526
DEP	453	15.51400	11.54072	11.16352
OVR	4246	10.68558	6.58978	6.13299

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.9458	2	4888	0.0010
Brown-Forsythe	58.2217	2	4888	<.0001
Levene	67.5119	2	4888	<.0001
Bartlett	69.3221	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
74.4201	2	388.08	<.0001

Figure A.1- 85 Statistical Tests for Horizontal Error and Flight Type at Look Ahead 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	192	2.45824	9.2059	0.66438
DEP	453	-2.41967	13.2625	0.62313
OVR	4246	-0.36431	10.4774	0.16079

Means Comparisons

Dif=Mean[i]-Mean[j]	ARR	OVR	DEP
ARR	0.00000	2.82254	4.87791
OVR	-2.82254	0.00000	2.05537
DEP	-4.87791	-2.05537	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	ARR	OVR	DEP
ARR	-2.56497	0.96828	2.71371
OVR	0.96828	-0.54543	0.81320
DEP	2.71371	0.81320	-1.66987

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	192	9.20588	5.485769	4.839015
DEP	453	13.26254	7.757803	7.047101
OVR	4246	10.47740	4.954473	4.880312

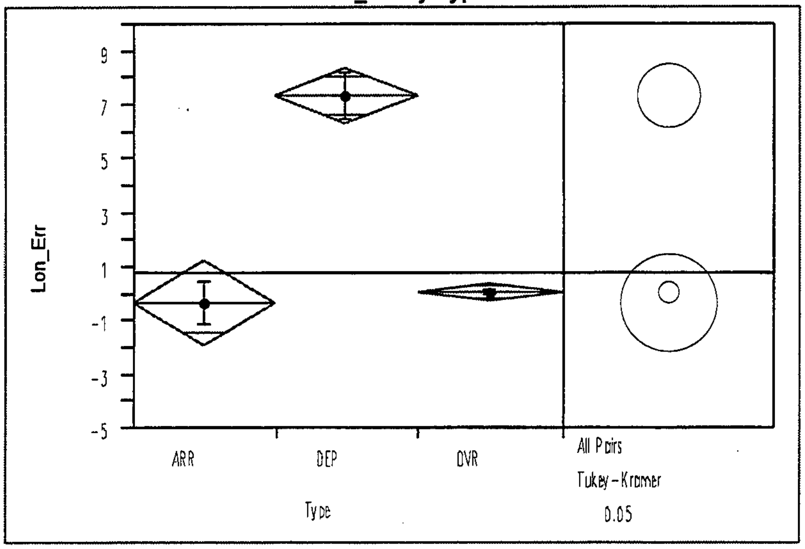
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.2232	2	4888	0.1084
Brown-Forsythe	10.7965	2	4888	<.0001
Levene	18.5959	2	4888	<.0001
Bartlett	29.8818	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.4264	2	400.05	<.0001

Figure A.1- 86 Statistical Tests for Lateral Error and Flight Type at Look Ahead 1800 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Type



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	192	-0.28145	11.6697	0.84218
DEP	453	7.35761	19.0312	0.89416
OVR	4246	0.12236	9.9857	0.15325

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	ARR
DEP	0.00000	7.23525	7.63906
OVR	-7.23525	0.00000	0.40382
ARR	-7.63906	-0.40382	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	DEP	OVR	ARR
DEP	-1.74448	5.93757	5.37816
OVR	5.93757	-0.56980	-1.53329
ARR	5.37816	-1.53329	-2.67957

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

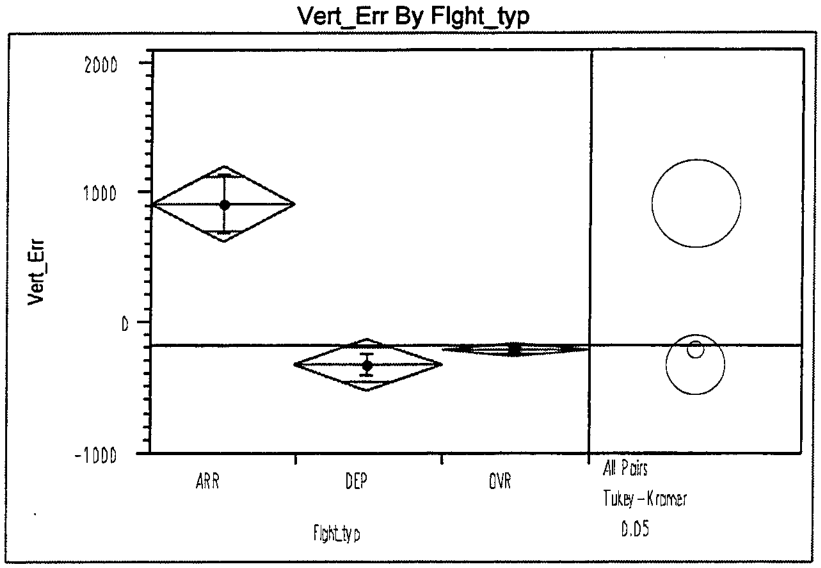
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	192	11.66965	6.81430	6.80113
DEP	453	19.03118	13.86243	13.85707
OVR	4246	9.98569	6.81711	6.81249

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	86.6965	2	4888	<.0001
Brown-Forsythe	155.5814	2	4888	<.0001
Levene	155.9712	2	4888	<.0001
Bartlett	238.7980	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
32.0015	2	380.57	<.0001

Figure A.1- 87 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	192	915.073	3306.58	238.63
DEP	453	-325.001	2054.36	96.52
OVR	4246	-214.247	2071.27	31.79

Means Comparisons

Dif=Mean[i]-Mean[j]	ARR	OVR	DEP
ARR	0.00	1129.32	1240.07
OVR	-1129.32	0.00	110.75
DEP	-1240.07	-110.75	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*

2.34442

Abs(Dif)-LSD	ARR	OVR	DEP
ARR	-510.016	760.620	809.745
OVR	760.620	-108.454	-136.239
DEP	809.745	-136.239	-332.036

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	192	3306.584	2495.533	2281.024
DEP	453	2054.355	1156.018	964.542
OVR	4246	2071.266	952.880	823.117

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.2822	2	4888	0.0139
Brown-Forsythe	52.4411	2	4888	<.0001
Levene	65.6802	2	4888	<.0001
Bartlett	54.4102	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
11.8078	2	387.5	<.0001

Figure A.1- 88 Statistical Tests for Vertical Error and Flight Type at Look Ahead 1800 for Samples at Altitudes Above 18,000 Feet

A.1.3 Horizontal Phase of Flight per Look Ahead Time

A.1.3.1 Summary Tables

Look Ahead Time	0		300	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	30644	5284	25710	4089
Avg. Horz. Error	1.19	1.29	3.16	3.17
Stddev. Horz. Error	1.05	1.27	3.38	3.53
Max. Horz. Error	42.39	16.91	84.31	65.56
Min. Horz. Error	0	0	0.01	0.03
Avg. Lat. Error	-0.02	-0.03	-0.11	-0.02
Stddev. Lat. Error	1.31	1.54	3.65	3.6
Max. Lat. Error	32.23	13.48	65.49	24.97
Min. Lat. Error	-12.79	-16	-39.47	-36.73
Avg. Abs. Lat. Error	0.86	0.96	1.98	1.98
Stddev. Abs. Lat. Error	0.99	1.2	3.07	3
Max. Abs. Lat. Error	32.23	16	65.49	36.73
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.01	-0.06	0.12	-0.11
Stddev. Long. Error	0.9	0.95	2.84	3.09
Max. Long. Error	11.93	9.33	25.52	22.3
Min. Long. Error	-27.53	-9.81	-63.13	-65.39
Avg. Abs. Long. Error	0.6	0.64	1.87	1.92
Stddev. Abs. Long. Error	0.67	0.71	2.13	2.41
Max. Abs. Long. Error	27.53	9.81	63.13	65.39
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	47.19	61.93	-5.09	-18.64
Stddev. Vert. Error	649.95	733.67	1611.37	1623.68
Max. Vert. Error	36817	21071.71	34817	9649
Min. Vert. Error	-6824.15	-4734	-12626.9	-12244.5
Avg. Abs. Vert. Error	193.1	268.05	726.83	788.28
Stddev. Abs. Vert. Error	622.39	685.74	1438.14	1419.56
Max. Abs. Vert. Error	36817	21071.71	34817	12244.45
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	1.19	1.3	3.18	3.18
Stddev. Slant Range Error	1.05	1.27	3.37	3.52
Max. Slant Range Error	42.39	16.91	84.34	65.56
Min. Slant Range Error	0	0	0.01	0.04

Figure A.1- 89 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	600		900	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	20696	3268	15904	2625
Avg. Horz. Error	5.16	4.81	6.88	6.48
Stddev. Horz. Error	5.49	5.3	7.32	7.05
Max. Horz. Error	125.68	92.46	167.79	150.3
Min. Horz. Error	0.02	0.03	0.02	0.05
Avg. Lat. Error	-0.19	-0.05	-0.23	-0.15
Stddev. Lat. Error	5.49	5.05	7.07	6.42
Max. Lat. Error	97.45	71.88	129.48	115.83
Min. Lat. Error	-61.74	-53.06	-94.55	-59.15
Avg. Abs. Lat. Error	2.9	2.61	3.66	3.19
Stddev. Abs. Lat. Error	4.66	4.32	6.05	5.57
Max. Abs. Lat. Error	97.45	71.88	129.48	115.83
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.44	-0.14	0.59	0.11
Stddev. Long. Error	5.13	5.06	7.11	7.1
Max. Long. Error	91.73	67.54	94.25	41.71
Min. Long. Error	-79.36	-58.15	-106.71	-95.77
Avg. Abs. Long. Error	3.31	3.27	4.59	4.64
Stddev. Abs. Long. Error	3.95	3.87	5.45	5.37
Max. Abs. Long. Error	91.73	67.54	106.71	95.77
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-118	-180.93	-180.03	-204.44
Stddev. Vert. Error	1956.29	1989.43	2003.17	2027.8
Max. Vert. Error	28933	14957.77	30746.5	25785.61
Min. Vert. Error	-15373.8	-12081.6	-16419.3	-14157.8
Avg. Abs. Vert. Error	908.33	978.49	932.57	1025.48
Stddev. Abs. Vert. Error	1736.63	1741.51	1781.95	1761.19
Max. Abs. Vert. Error	28933	14957.77	30746.5	25785.61
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	5.17	4.82	6.89	6.5
Stddev. Slant Range Error	5.49	5.29	7.31	7.04
Max. Slant Range Error	125.72	92.49	167.86	150.36
Min. Slant Range Error	0.02	0.03	0.03	0.05

Figure A.1- 90 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1200		1500	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	11777	2059	8172	1506
Avg. Horz. Error	8.36	7.62	9.47	8.78
Stddev. Horz. Error	9.08	7.68	10.29	8.93
Max. Horz. Error	173.62	59.78	156.35	75.02
Min. Horz. Error	0.02	0.05	0.01	0.09
Avg. Lat. Error	-0.19	-0.35	-0.25	-0.2
Stddev. Lat. Error	8.7	6.49	9.8	7.6
Max. Lat. Error	134.87	37.52	120.34	43.04
Min. Lat. Error	-124.94	-58.31	-143.49	-74.28
Avg. Abs. Lat. Error	4.31	3.31	4.74	3.69
Stddev. Abs. Lat. Error	7.56	5.59	8.58	6.64
Max. Abs. Lat. Error	134.87	58.31	143.49	74.28
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.78	0.23	0.91	0.15
Stddev. Long. Error	8.71	8.65	9.93	9.95
Max. Long. Error	96.16	52.72	97.63	57.59
Min. Long. Error	-109.33	-58.39	-99.82	-56.73
Avg. Abs. Long. Error	5.71	5.82	6.61	6.79
Stddev. Abs. Long. Error	6.63	6.41	7.46	7.27
Max. Abs. Long. Error	109.33	58.39	99.82	57.59
Min. Abs. Long. Error	0	0.01	0	0
Avg. Vert. Error	-211.73	-137.64	-273.57	-273.83
Stddev. Vert. Error	2118.95	2082.79	2206.29	2285.65
Max. Vert. Error	37473.73	22311.16	38907.87	13328.09
Min. Vert. Error	-15900	-11900	-15900	-17219.3
Avg. Abs. Vert. Error	974.42	1079.43	1034.06	1237.03
Stddev. Abs. Vert. Error	1893.47	1786.4	1968.04	1941.13
Max. Abs. Vert. Error	37473.73	22311.16	38907.87	17219.3
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	8.37	7.63	9.48	8.79
Stddev. Slant Range Error	9.07	7.68	10.29	8.92
Max. Slant Range Error	173.7	59.78	156.48	75.02
Min. Slant Range Error	0.02	0.05	0.01	0.12

Figure A.1- 91 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1800	
Horizontal Phase of Flight	Straight	Turn
Sample Quantity	5374	1070
Avg. Horz. Error	10.36	9.2
Stddev. Horz. Error	11.13	9.6
Max. Horz. Error	169.84	112.98
Min. Horz. Error	0.04	0.22
Avg. Lat. Error	-0.25	-0.08
Stddev. Lat. Error	10.33	8.55
Max. Lat. Error	117.09	53.32
Min. Lat. Error	-155.99	-91.1
Avg. Abs. Lat. Error	4.97	3.63
Stddev. Abs. Lat. Error	9.06	7.74
Max. Abs. Lat. Error	155.99	91.1
Min. Abs. Lat. Error	0	0
Avg. Long. Error	1.03	0.12
Stddev. Long. Error	11.11	10.19
Max. Long. Error	98.01	41.35
Min. Long. Error	-78.53	-66.82
Avg. Abs. Long. Error	7.46	7.23
Stddev. Abs. Long. Error	8.29	7.18
Max. Abs. Long. Error	98.01	66.82
Min. Abs. Long. Error	0	0.01
Avg. Vert. Error	-353.57	-194.44
Stddev. Vert. Error	2288.19	2344.76
Max. Vert. Error	31668.16	23241.93
Min. Vert. Error	-15800	-10068.2
Avg. Abs. Vert. Error	1079.65	1199.17
Stddev. Abs. Vert. Error	2048.16	2023.96
Max. Abs. Vert. Error	31668.16	23241.93
Min. Abs. Vert. Error	0	0
Avg. Slant Range Error	10.37	9.21
Stddev. Slant Range Error	11.12	9.6
Max. Slant Range Error	169.84	112.98
Min. Slant Range Error	0.04	0.23

Figure A.1- 92 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	0		300	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	23358	2790	20257	2243
Avg. Horz. Error	1.14	1.12	3.17	3.25
Stddev. Horz. Error	0.96	0.81	3.51	3.8
Max. Horz. Error	42.39	8.85	84.31	65.56
Min. Horz. Error	0	0	0.01	0.03
Avg. Lat. Error	-0.03	-0.02	-0.12	-0.11
Stddev. Lat. Error	1.21	1.15	3.79	3.91
Max. Lat. Error	32.23	7.19	65.49	24.97
Min. Lat. Error	-6.04	-4.23	-39.47	-36.73
Avg. Abs. Lat. Error	0.8	0.8	2.02	2.07
Stddev. Abs. Lat. Error	0.9	0.82	3.21	3.32
Max. Abs. Lat. Error	32.23	7.19	65.49	36.73
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.02	-0.05	0.14	-0.03
Stddev. Long. Error	0.87	0.78	2.83	3.12
Max. Long. Error	11.93	8.82	25.52	22.3
Min. Long. Error	-27.53	-4.14	-63.13	-65.39
Avg. Abs. Long. Error	0.59	0.6	1.84	1.9
Stddev. Abs. Long. Error	0.64	0.5	2.16	2.48
Max. Abs. Long. Error	27.53	8.82	63.13	65.39
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	38.33	42.51	51.55	132.07
Stddev. Vert. Error	591.23	597.13	1466.04	1342.85
Max. Vert. Error	36817	21071.71	34817	9649
Min. Vert. Error	-1838.97	-2800	-10304.6	-6590
Avg. Abs. Vert. Error	135.31	150.04	598.37	582.81
Stddev. Abs. Vert. Error	576.81	579.53	1339.36	1216.91
Max. Abs. Vert. Error	36817	21071.71	34817	9649
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	1.14	1.12	3.19	3.26
Stddev. Slant Range Error	0.96	0.82	3.51	3.8
Max. Slant Range Error	42.39	8.85	84.34	65.56
Min. Slant Range Error	0	0	0.01	0.04

Figure A.1- 93 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	600		900	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	16318	1892	12490	1482
Avg. Horz. Error	5.24	5.06	7.02	6.72
Stddev. Horz. Error	5.7	5.75	7.64	7.69
Max. Horz. Error	125.68	92.46	167.79	150.3
Min. Horz. Error	0.02	0.03	0.03	0.06
Avg. Lat. Error	-0.26	0	-0.26	-0.46
Stddev. Lat. Error	5.82	5.78	7.61	7.37
Max. Lat. Error	97.45	71.88	129.48	115.83
Min. Lat. Error	-61.74	-53.06	-94.55	-59.15
Avg. Abs. Lat. Error	3.08	2.89	3.95	3.58
Stddev. Abs. Lat. Error	4.95	5	6.5	6.46
Max. Abs. Lat. Error	97.45	71.88	129.48	115.83
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.46	-0.09	0.57	0.34
Stddev. Long. Error	5.07	5.03	7.03	7.04
Max. Long. Error	91.73	25.18	94.25	27.07
Min. Long. Error	-79.36	-58.15	-106.71	-95.77
Avg. Abs. Long. Error	3.24	3.32	4.49	4.53
Stddev. Abs. Long. Error	3.93	3.77	5.45	5.4
Max. Abs. Long. Error	91.73	58.15	106.71	95.77
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	10.08	39.12	-49.65	15.95
Stddev. Vert. Error	1820.98	1808.85	1853.61	1840.69
Max. Vert. Error	28933	14957.77	30746.5	25785.61
Min. Vert. Error	-10552	-9300	-10700	-8585.77
Avg. Abs. Vert. Error	771.03	779.41	779.51	775.96
Stddev. Abs. Vert. Error	1649.71	1632.69	1682.45	1669.09
Max. Abs. Vert. Error	28933	14957.77	30746.5	25785.61
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	5.25	5.07	7.03	6.73
Stddev. Slant Range Error	5.69	5.75	7.64	7.69
Max. Slant Range Error	125.72	92.49	167.86	150.36
Min. Slant Range Error	0.02	0.03	0.03	0.06

Figure A.1- 94 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

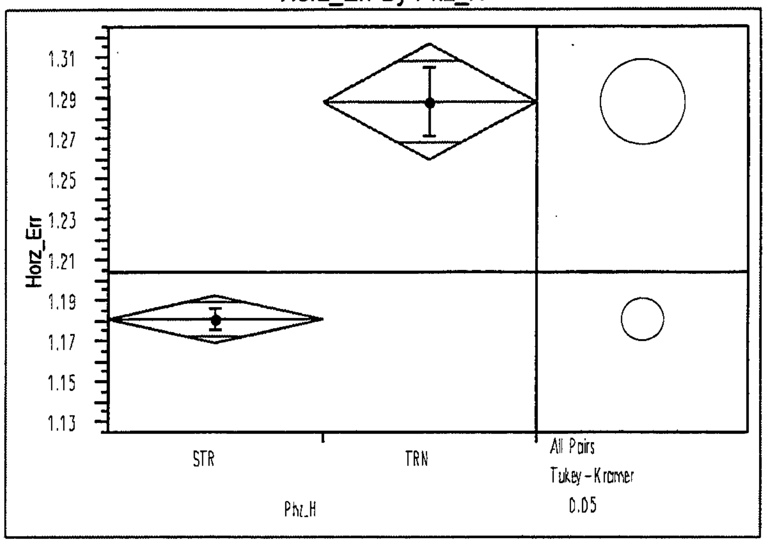
Look Ahead Time	1200		1500	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	9175	1199	6431	876
Avg. Horz. Error	8.54	7.77	9.75	8.85
Stddev. Horz. Error	9.51	7.65	10.83	8.97
Max. Horz. Error	173.62	59.59	156.35	75.02
Min. Horz. Error	0.02	0.05	0.01	0.12
Avg. Lat. Error	-0.21	-0.66	-0.33	-0.74
Stddev. Lat. Error	9.39	7.4	10.51	8.11
Max. Lat. Error	134.87	31.72	120.34	43.04
Min. Lat. Error	-124.94	-58.31	-143.49	-74.28
Avg. Abs. Lat. Error	4.71	3.67	5.13	3.89
Stddev. Abs. Lat. Error	8.12	6.46	9.17	7.15
Max. Abs. Lat. Error	134.87	58.31	143.49	74.28
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.84	0.51	0.92	0.44
Stddev. Long. Error	8.63	7.96	10.06	9.61
Max. Long. Error	96.16	33.16	97.63	57.59
Min. Long. Error	-109.33	-39.15	-99.82	-56.73
Avg. Abs. Long. Error	5.57	5.59	6.61	6.66
Stddev. Abs. Long. Error	6.65	5.69	7.63	6.94
Max. Abs. Long. Error	109.33	39.15	99.82	57.59
Min. Abs. Long. Error	0	0.01	0	0
Avg. Vert. Error	-111.93	-35.3	-173.17	-139.25
Stddev. Vert. Error	1930.07	1895.78	2047.12	1894.59
Max. Vert. Error	37473.73	22311.16	38907.87	13328.09
Min. Vert. Error	-10485.7	-7974.83	-9483.61	-8910.64
Avg. Abs. Vert. Error	771.12	819.37	836.94	858.13
Stddev. Abs. Vert. Error	1772.85	1709.76	1876.19	1694.6
Max. Abs. Vert. Error	37473.73	22311.16	38907.87	13328.09
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	8.55	7.78	9.76	8.86
Stddev. Slant Range Error	9.51	7.64	10.83	8.96
Max. Slant Range Error	173.7	59.59	156.48	75.02
Min. Slant Range Error	0.02	0.05	0.01	0.12

Figure A.1- 95 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	1800	
Horizontal Phase of Flight	Straight	Turn
Sample Quantity	4254	637
Avg. Horz. Error	10.78	9.51
Stddev. Horz. Error	11.7	10.41
Max. Horz. Error	169.84	112.98
Min. Horz. Error	0.04	0.24
Avg. Lat. Error	-0.4	-0.74
Stddev. Lat. Error	10.93	9.48
Max. Lat. Error	117.09	29.62
Min. Lat. Error	-155.99	-91.1
Avg. Abs. Lat. Error	5.27	3.83
Stddev. Abs. Lat. Error	9.58	8.7
Max. Abs. Lat. Error	155.99	91.1
Min. Abs. Lat. Error	0	0
Avg. Long. Error	0.95	-0.39
Stddev. Long. Error	11.52	10.41
Max. Long. Error	98.01	41.35
Min. Long. Error	-78.53	-66.82
Avg. Abs. Long. Error	7.66	7.31
Stddev. Abs. Long. Error	8.66	7.41
Max. Abs. Long. Error	98.01	66.82
Min. Abs. Long. Error	0	0.01
Avg. Vert. Error	-210.65	23.33
Stddev. Vert. Error	2127.36	2234.08
Max. Vert. Error	31668.16	23241.93
Min. Vert. Error	-10550	-8192.79
Avg. Abs. Vert. Error	885.61	945.76
Stddev. Abs. Vert. Error	1945.65	2023.8
Max. Abs. Vert. Error	31668.16	23241.93
Min. Abs. Vert. Error	0	0
Avg. Slant Range Error	10.8	9.52
Stddev. Slant Range Error	11.7	10.4
Max. Slant Range Error	169.84	112.98
Min. Slant Range Error	0.04	0.36

Figure A.1- 96 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

A.1.3.2 Statistical Tests



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	30644	1.18965	1.04870	0.00599
TRN	5284	1.29264	1.26544	0.01741

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.102987
STR	-0.10299	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96003

Abs(Dif)-LSD	TRN	STR
TRN	-0.04131	0.071358
STR	0.071358	-0.01715

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	30644	1.048704	0.7002294	0.6736421
TRN	5284	1.265439	0.7923162	0.7528604

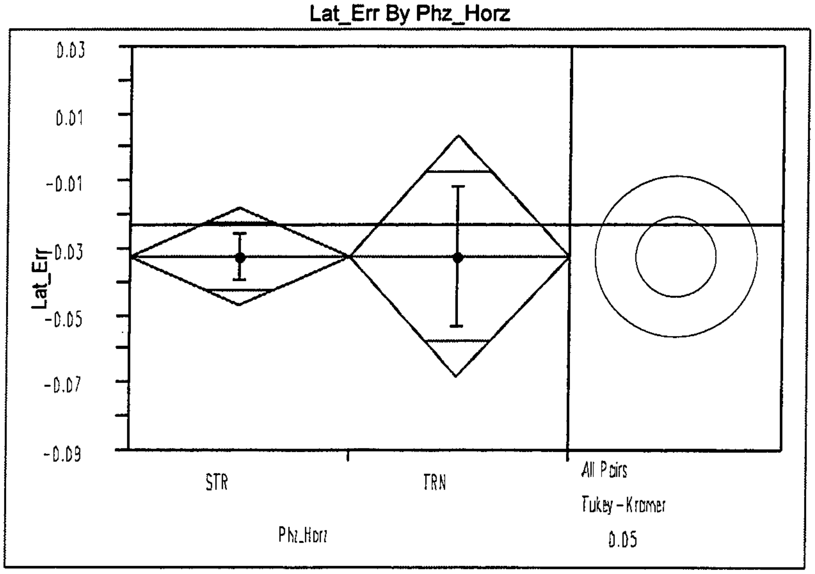
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	9.1359	1	35926	0.0025
Brown-Forsythe	37.0686	1	35926	<.0001
Levene	57.6468	1	35926	<.0001
Bartlett	346.9744	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
31.2921	1	6592.4	<.0001

t-Test
5.5939

Figure A.1- 97 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	30644	-0.02227	1.30628	0.00746
TRN	5284	-0.0265	1.53523	0.02112

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.004228
TRN	-0.00423	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96003

Abs(Dif)-LSD	STR	TRN
STR	-0.02126	-0.03496
TRN	-0.03496	-0.05119

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	30644	1.306283	0.8559916	0.8557251
TRN	5284	1.535231	0.9606380	0.9599589

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	28.5693	1	35926	<.0001
Brown-Forsythe	46.9795	1	35926	<.0001
Levene	47.3959	1	35926	<.0001
Bartlett	253.3457	1	?	<.0001

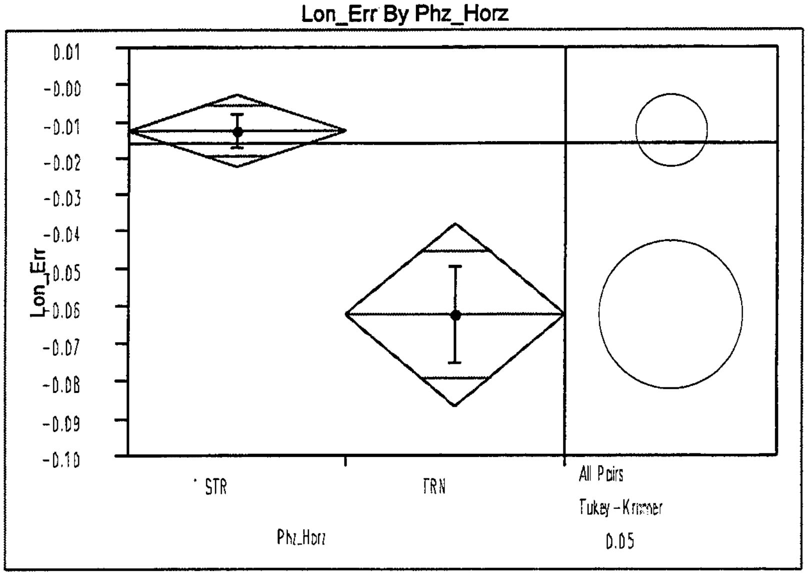
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.0356	1	6666.5	0.8503

t-Test
0.1888

Figure A.1- 98 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	30644	-0.00921	0.898964	0.00514
TRN	5284	-0.05507	0.954927	0.01314

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.045861
TRN	-0.04586	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96003

Abs(Dif)-LSD	STR	TRN
STR	-0.01437	0.019368
TRN	0.019368	-0.0346

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	30644	0.8989641	0.6020186	0.6020029
TRN	5284	0.9549275	0.6440687	0.6434889

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.2949	1	35926	0.2552
Brown-Forsythe	17.1044	1	35926	<.0001
Levene	17.5826	1	35926	<.0001
Bartlett	33.8112	1	?	<.0001

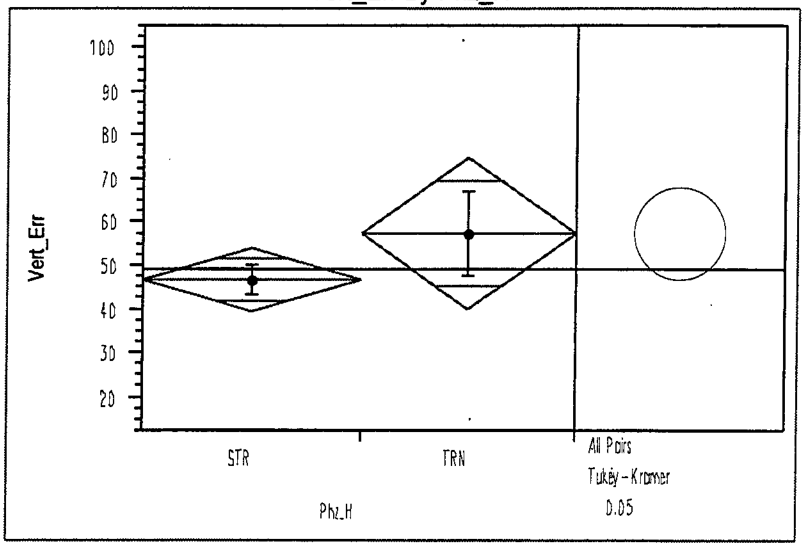
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
10.5717	1	6992.8	0.0012

t-Test
3.2514

Figure A.1- 99 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Vert_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	30644	47.1888	649.950	3.713
TRN	5284	61.9253	733.672	10.093

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.0000	14.7365
STR	-14.7365	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96003

Abs(Dif)-LSD	TRN	STR
TRN	-25.2791	-4.6183
STR	-4.6183	-10.4971

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	30644	649.9503	217.6595	193.1017
TRN	5284	733.6721	292.4736	268.0528

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.5220	1	35926	0.4700
Brown-Forsythe	63.3651	1	35926	<.0001
Levene	65.2706	1	35926	<.0001
Bartlett	139.9948	1	?	<.0001

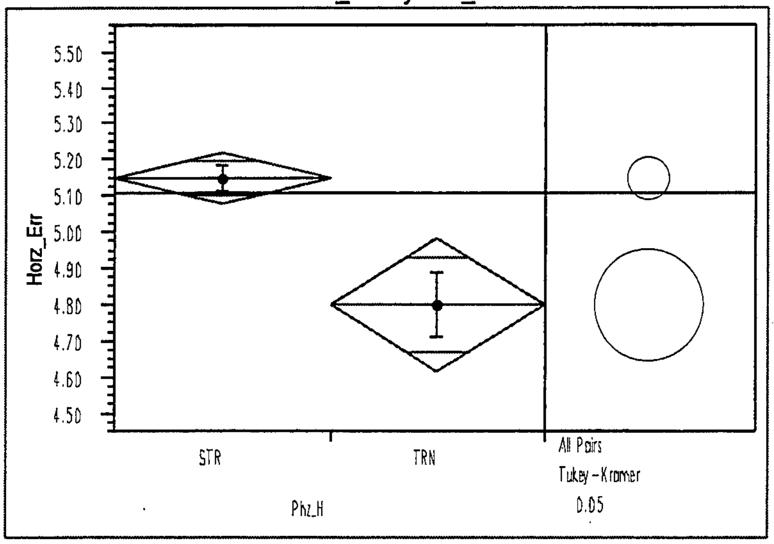
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.8777	1	6788.1	0.1706

t-Test
1.3703

Figure A.1- 100 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Horz_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	20696	5.15568	5.49140	0.03817
TRN	3268	4.80602	5.29839	0.09268

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.349667
TRN	-0.34967	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	STR	TRN
STR	-0.10531	0.148018
TRN	0.148018	-0.26502

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	20696	5.491399	3.696338	3.394160
TRN	3268	5.298388	3.416439	3.143605

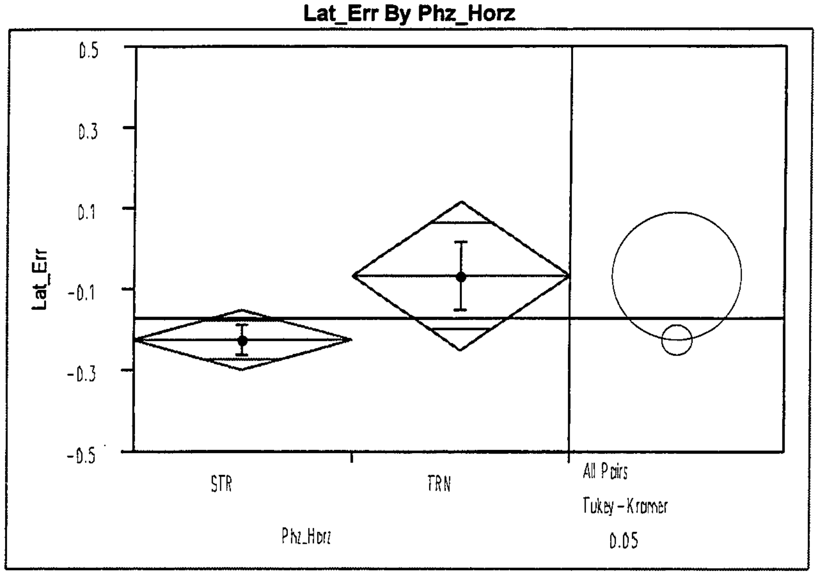
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.3511	1	23962	0.5535
Brown-Forsythe	8.2575	1	23962	0.0041
Levene	13.4178	1	23962	0.0002
Bartlett	7.0994	1	?	0.0077

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
12.1691	1	4449.1	0.0005

t-Test
3.4884

Figure A.1- 101 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	20696	-0.18927	5.49054	0.03817
TRN	3268	-0.05444	5.05091	0.08835

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.134832
STR	-0.13483	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	TRN	STR
TRN	-0.26343	-0.06561
STR	-0.06561	-0.10468

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	20696	5.490536	2.923887	2.903638
TRN	3268	5.050909	2.617246	2.614011

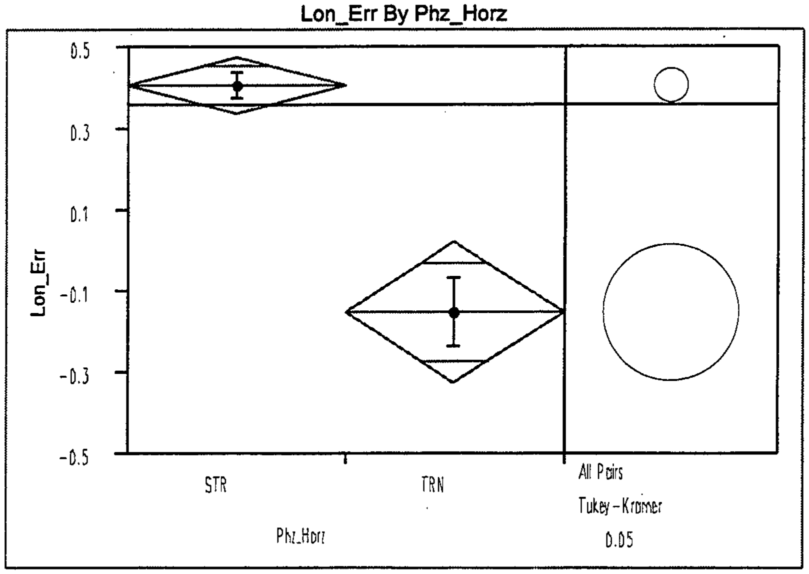
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.2794	1	23962	0.0702
Brown-Forsythe	11.0991	1	23962	0.0009
Levene	12.5203	1	23962	0.0004
Bartlett	37.7387	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.9626	1	4574.8	0.1613

t-Test
1.4009

Figure A.1- 102 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	20696	0.440978	5.13435	0.03569
TRN	3268	-0.14195	5.06389	0.08858

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.582923
TRN	-0.58292	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	STR	TRN
STR	-0.09875	0.393844
TRN	0.393844	-0.2485

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

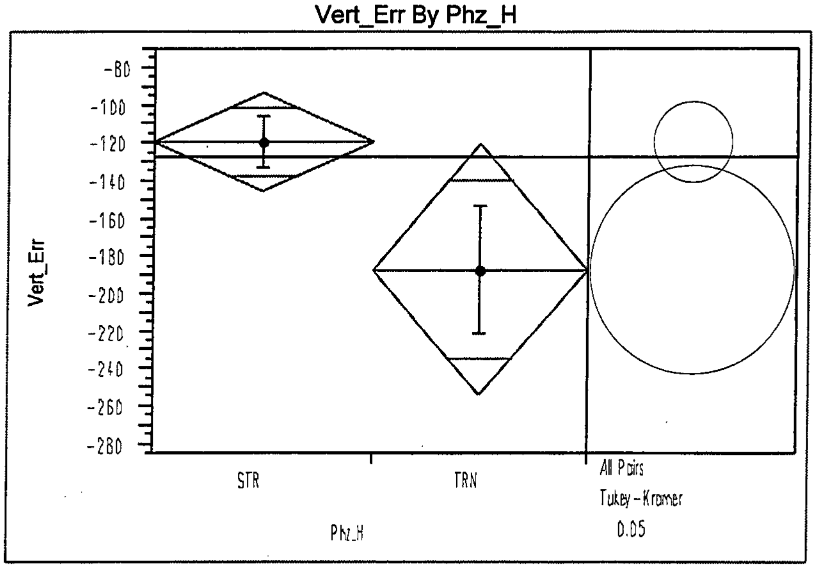
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	20696	5.134348	3.305220	3.302728
TRN	3268	5.063891	3.272833	3.268000

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0758	1	23962	0.7830
Brown-Forsythe	0.2209	1	23962	0.6383
Levene	0.1926	1	23962	0.6607
Bartlett	1.0701	1	?	0.3009

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
37.2569	1	4395.5	<.0001
t-Test			
6.1038			

Figure A.1- 103 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	20696	-117.996	1956.29	13.598
TRN	3268	-180.929	1989.43	34.801

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.0000	62.9333
TRN	-62.9333	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
1.96007

Abs(Dif)-LSD	STR	TRN
STR	-37.7820	-9.4117
TRN	-9.4117	-95.0795

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	20696	1956.291	967.748	908.3291
TRN	3268	1989.430	1059.898	978.4901

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.2293	1	23962	0.6321
Brown-Forsythe	4.6031	1	23962	0.0319
Levene	8.3135	1	23962	0.0039
Bartlett	1.6052	1	?	0.2052

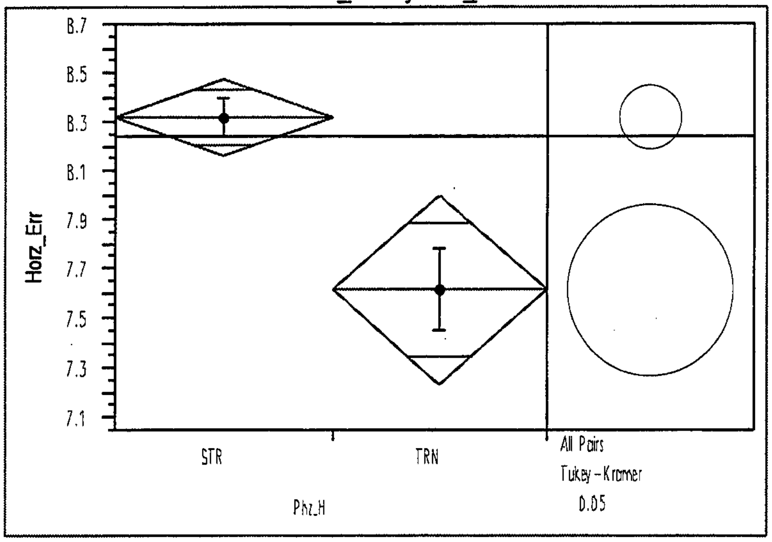
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.8371	1	4324.9	0.0922

t-Test
1.6844

Figure A.1- 104 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Horz_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	11777	8.35655	9.07761	0.08365
TRN	2059	7.62214	7.68013	0.16925

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.734415
TRN	-0.73442	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96014

Abs(Dif)-LSD	STR	TRN
STR	-0.22692	0.318468
TRN	0.318468	-0.54271

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	11777	9.077615	5.894810	5.459758
TRN	2059	7.680126	5.365415	4.950048

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.7312	1	13834	0.0534
Brown-Forsythe	8.0307	1	13834	0.0046
Levene	10.9023	1	13834	0.0010
Bartlett	90.4771	1	?	<.0001

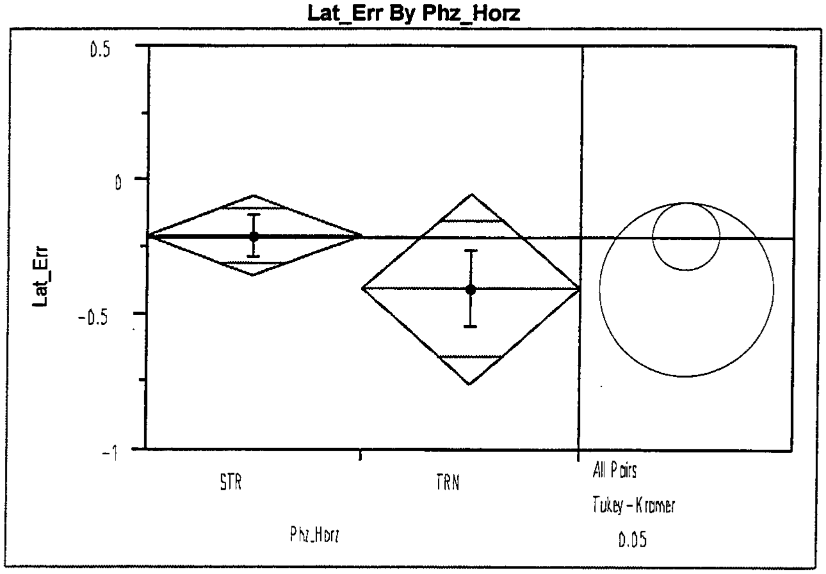
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
15.1320	1	3153.2	0.0001

t-Test

3.8900

Figure A.1- 105 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	11777	-0.18974	8.69899	0.08016
TRN	2059	-0.34514	6.48552	0.14293

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.155399
TRN	-0.1554	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96014

Abs(Dif)-LSD	STR	TRN
STR	-0.21474	-0.23822
TRN	-0.23822	-0.51357

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	11777	8.698985	4.327187	4.305173
TRN	2059	6.485523	3.369102	3.310283

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	12.0914	1	13834	0.0005
Brown-Forsythe	32.5365	1	13834	<.0001
Levene	30.3294	1	13834	<.0001
Bartlett	262.8820	1	?	<.0001

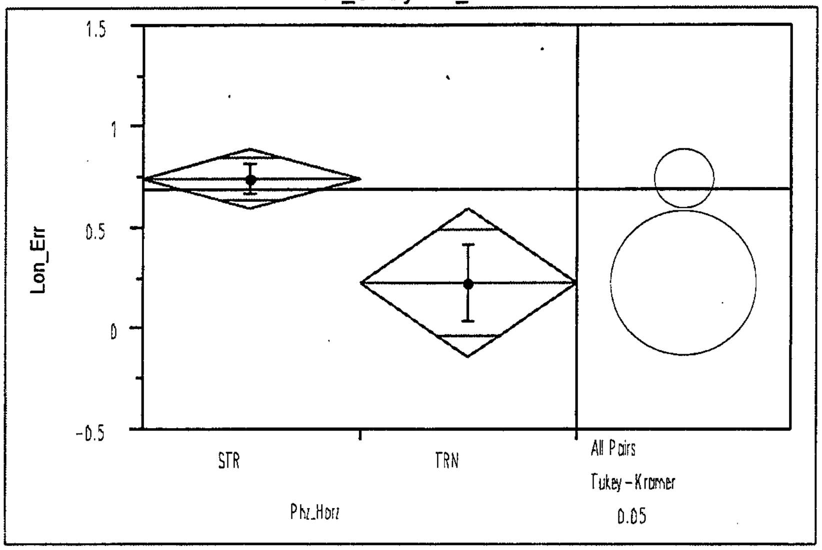
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.8993	1	3495.8	0.3430

t-Test

0.9483

Figure A.1- 106 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	11777	0.775014	8.71389	0.08030
TRN	2059	0.234513	8.65294	0.19069

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.540501
TRN	-0.5405	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96014

Abs(Dif)-LSD	STR	TRN
STR	-0.22235	0.132926
TRN	0.132926	-0.53178

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	11777	8.713893	5.676709	5.676294
TRN	2059	8.652936	5.808816	5.807731

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0194	1	13834	0.8891
Brown-Forsythe	0.6987	1	13834	0.4032
Levene	0.7061	1	13834	0.4008
Bartlett	0.1721	1	?	0.6783

Welch Anova testing Means Equal, allowing Std's Not Equal

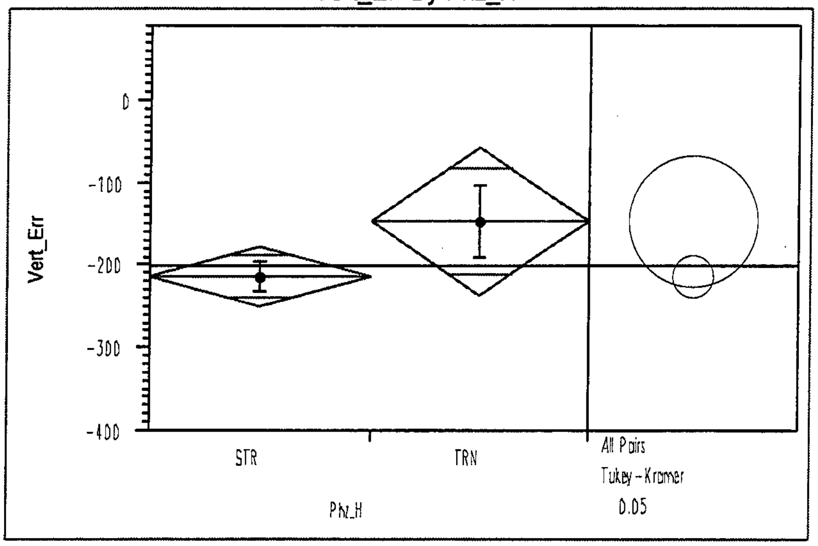
F Ratio	DF Num	DF Den	Prob>F
6.8239	1	2836.9	0.0090

t-Test

2.6123

Figure A.1- 107 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Vert_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	11777	-211.733	2118.95	19.526
TRN	2059	-137.636	2082.79	45.901

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.0000	74.0965
STR	-74.0965	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96014

Abs(Dif)-LSD	TRN	STR
TRN	-129.122	-24.866
STR	-24.866	-53.990

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	11777	2118.952	1083.927	974.422
TRN	2059	2082.791	1137.760	1079.431

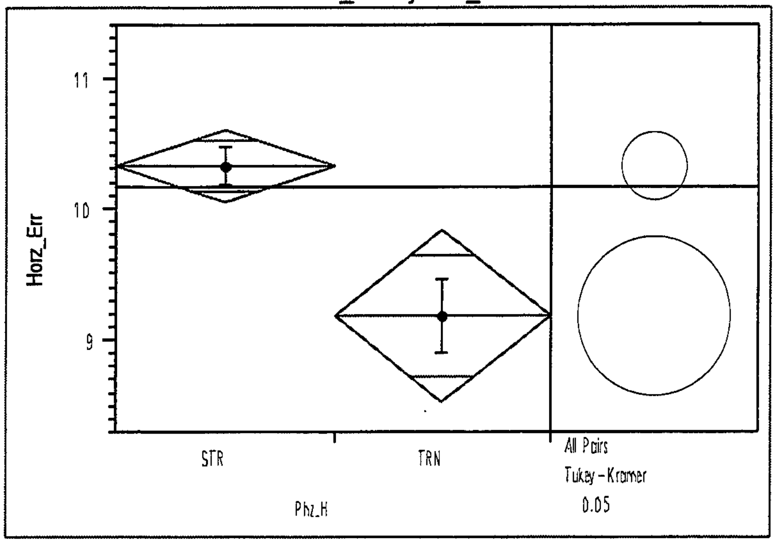
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0647	1	13834	0.7993
Brown-Forsythe	5.4800	1	13834	0.0192
Levene	1.5511	1	13834	0.2130
Bartlett	1.0296	1	?	0.3103

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.2066	1	2853.9	0.1375
t-Test			
1.4855			

Figure A.1- 108 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Horz_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5374	10.3600	11.1290	0.15181
TRN	1070	9.1972	9.6037	0.29359

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.00000	1.16277
TRN	-1.16277	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96033

Abs(Dif)-LSD	STR	TRN
STR	-0.41186	0.448073
TRN	0.448073	-0.92301

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5374	11.12897	7.176342	6.645693
TRN	1070	9.60369	6.144044	5.673951

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.3236	1	6442	0.1275
Brown-Forsythe	9.8134	1	6442	0.0017
Levene	13.7068	1	6442	0.0002
Bartlett	36.2444	1	?	<.0001

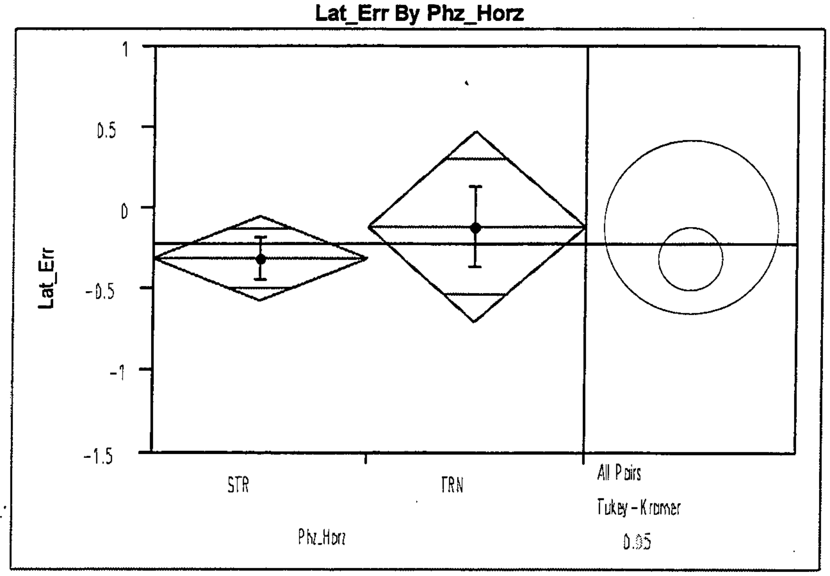
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
12.3762	1	1693	0.0004

t-Test

3.5180

Figure A.1- 109 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5374	-0.24902	10.3318	0.14094
TRN	1070	-0.08491	8.5473	0.26130

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.164114
STR	-0.16411	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96033

Abs(Dif)-LSD	TRN	STR
TRN	-0.85241	-0.49591
STR	-0.49591	-0.38036

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5374	10.33181	5.002420	4.965469
TRN	1070	8.54733	3.637925	3.623850

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.8305	1	6442	0.0925
Brown-Forsythe	20.4680	1	6442	<.0001
Levene	21.2774	1	6442	<.0001
Bartlett	58.8292	1	?	<.0001

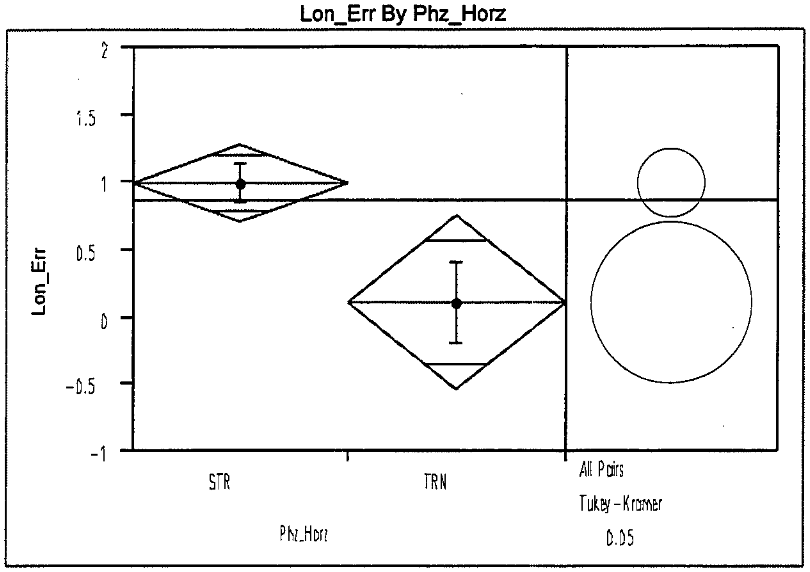
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.3056	1	1752	0.5805

t-Test

0.5528

Figure A.1- 110 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5374	1.02607	11.1059	0.15150
TRN	1070	0.11968	10.1892	0.31149

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.906391
TRN	-0.90639	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96033

Abs(Dif)-LSD	STR	TRN
STR	-0.41445	0.187202
TRN	0.187202	-0.92881

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5374	11.10594	7.405065	7.404787
TRN	1070	10.18923	7.222062	7.219848

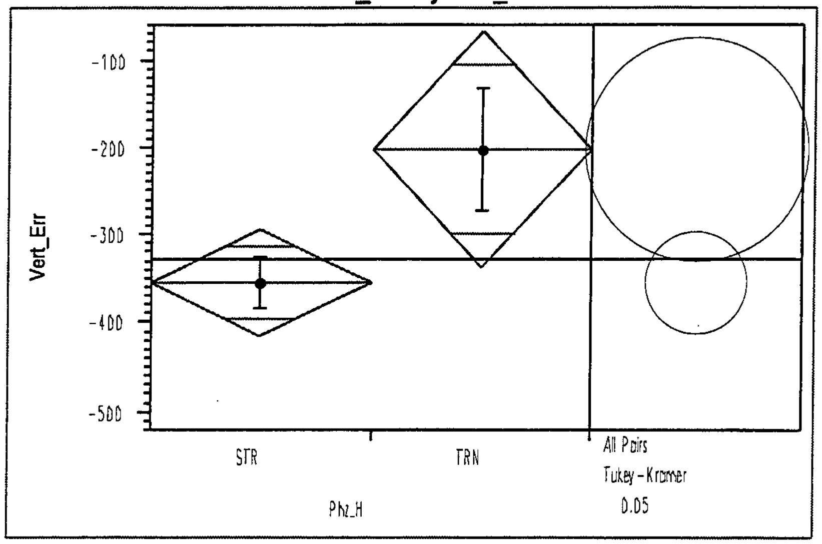
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.4553	1	6442	0.1172
Brown-Forsythe	0.4644	1	6442	0.4956
Levene	0.4549	1	6442	0.5000
Bartlett	12.7285	1	?	0.0004

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.8474	1	1616.6	0.0090

t-Test
2.6167

Figure A.1- 111 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5374	-353.572	2288.19	31.213
TRN	1070	-194.444	2344.76	71.681

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000	159.127
STR	-159.127	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96033

Abs(Dif)-LSD	TRN	STR
TRN	-194.734	8.344
STR	8.344	-86.893

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5374	2288.185	1260.318	1079.647
TRN	1070	2344.763	1278.268	1199.168

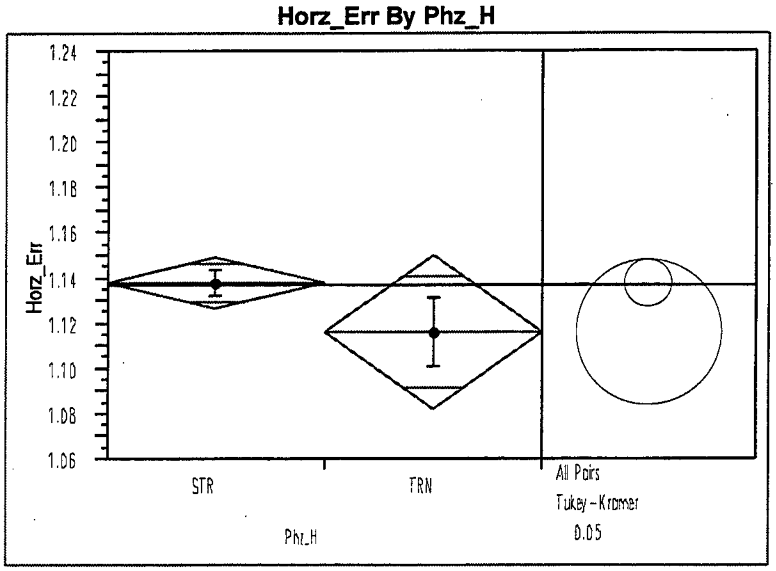
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0756	1	6442	0.7834
Brown-Forsythe	3.0506	1	6442	0.0808
Levene	0.0781	1	6442	0.7799
Bartlett	1.0751	1	?	0.2998

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
4.1426	1	1502.1	0.0420

t-Test
2.0353

Figure A.1- 112 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	23358	1.13878	0.956849	0.00626
TRN	2790	1.12099	0.814684	0.01542

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.017799
TRN	-0.0178	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96006

Abs(Dif)-LSD	STR	TRN
STR	-0.0171	-0.01921
TRN	-0.01921	-0.04947

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	23358	0.9568488	0.6543072	0.6331895
TRN	2790	0.8146839	0.6252144	0.6084381

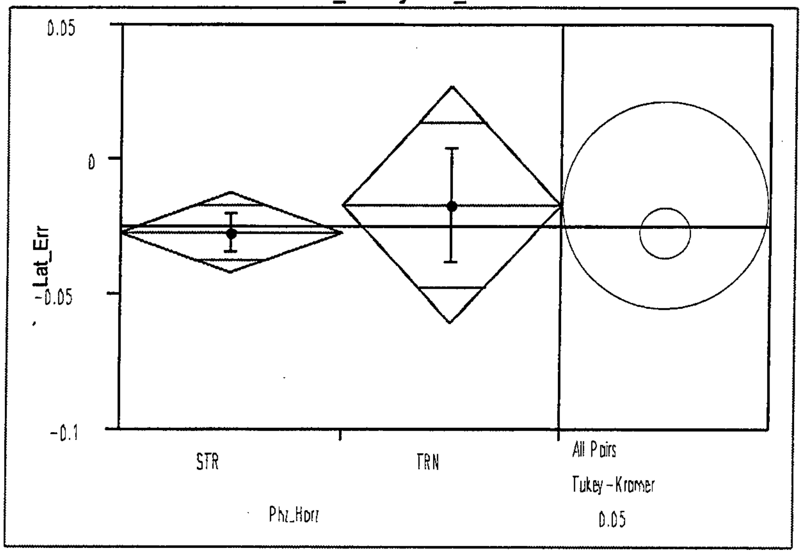
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.1246	1	26146	0.2889
Brown-Forsythe	2.8779	1	26146	0.0898
Levene	4.5412	1	26146	0.0331
Bartlett	118.5084	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.1433	1	3771.6	0.2850
t-Test			
1.0693			

Figure A.1- 113 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	23358	-0.02597	1.20545	0.00789
TRN	2790	-0.01611	1.14651	0.02171

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.009859
STR	-0.00986	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96006

Abs(Dif)-LSD	TRN	STR
TRN	-0.06294	-0.03723
STR	-0.03723	-0.02175

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	23358	1.205451	0.8046062	0.8042065
TRN	2790	1.146515	0.7982615	0.7978787

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.8749	1	26146	0.3496
Brown-Forsythe	0.1258	1	26146	0.7228
Levene	0.1267	1	26146	0.7219
Bartlett	12.1946	1	?	0.0005

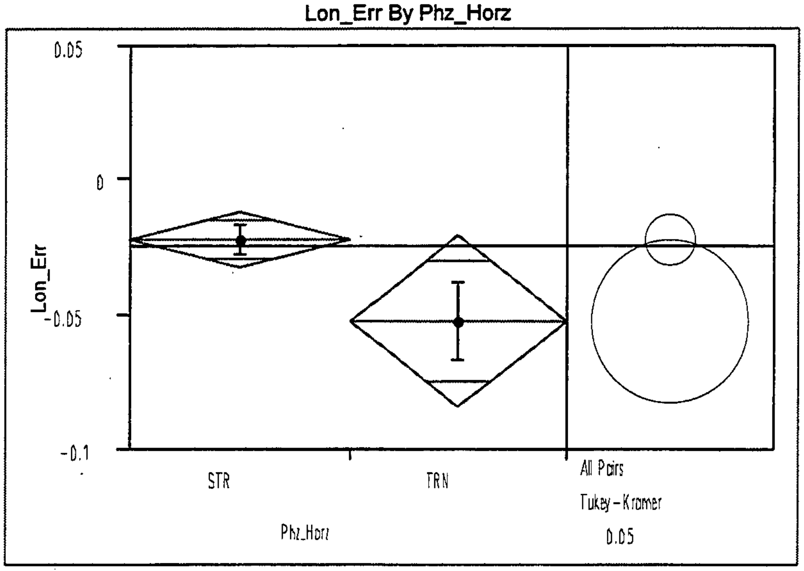
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.1822	1	3566.7	0.6695

t-Test
0.4269

Figure A.1- 114 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	23358	-0.02193	0.870736	0.00570
TRN	2790	-0.04635	0.777087	0.01471

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.024420
TRN	-0.02442	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96006

Abs(Dif)-LSD	STR	TRN
STR	-0.01562	-0.00939
TRN	-0.00939	-0.0452

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	23358	0.8707357	0.5903900	0.5903219
TRN	2790	0.7770872	0.5965265	0.5965178

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.3093	1	26146	0.2525
Brown-Forsythe	0.2437	1	26146	0.6215
Levene	0.2392	1	26146	0.6248
Bartlett	60.7791	1	?	<.0001

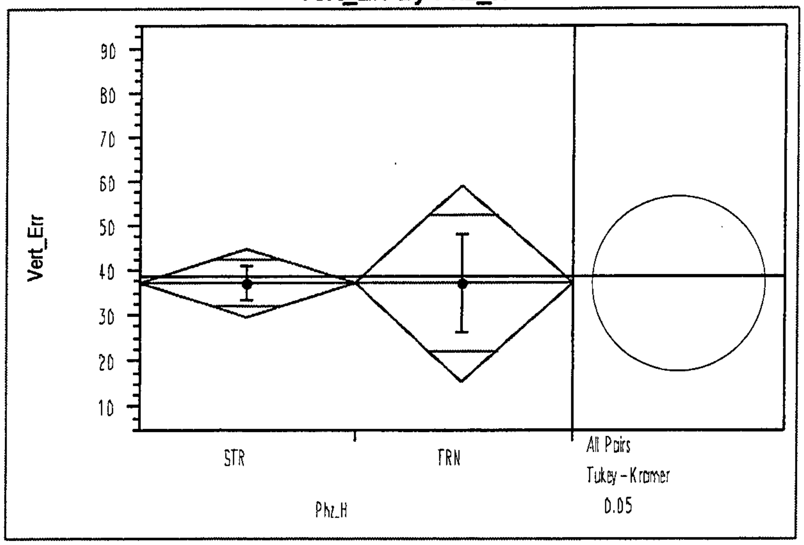
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.3960	1	3678.4	0.1217

t-Test
1.5479

Figure A.1- 115 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	23358	38.3347	591.230	3.868
TRN	2790	42.5057	597.128	11.305

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.00000	4.17099
STR	-4.17099	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96006

Abs(Dif)-LSD	TRN	STR
TRN	-31.0601	-19.0665
STR	-19.0665	-10.7346

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	23358	591.2304	159.2353	135.3072
TRN	2790	597.1281	173.5532	150.0385

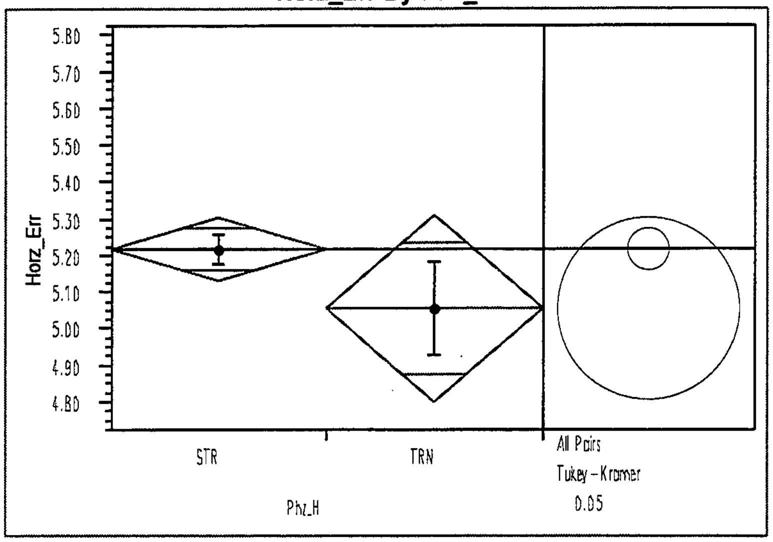
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0008	1	26146	0.9776
Brown-Forsythe	1.6240	1	26146	0.2026
Levene	1.5748	1	26146	0.2095
Bartlett	0.4934	1	?	0.4824

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.1219	1	3474.7	0.7270
t-Test			
0.3491			

Figure A.1- 116 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	16318	5.23890	5.69627	0.04459
TRN	1892	5.05890	5.74944	0.13218

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.180003
TRN	-0.18	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96010

Abs(Dif)-LSD	STR	TRN
STR	-0.12373	-0.09142
TRN	-0.09142	-0.36337

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	16318	5.696270	3.835836	3.501459
TRN	1892	5.749441	3.717368	3.372649

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0153	1	18208	0.9016
Brown-Forsythe	1.1879	1	18208	0.2758
Levene	1.3302	1	18208	0.2488
Bartlett	0.2940	1	?	0.5877

Welch Anova testing Means Equal, allowing Std's Not Equal

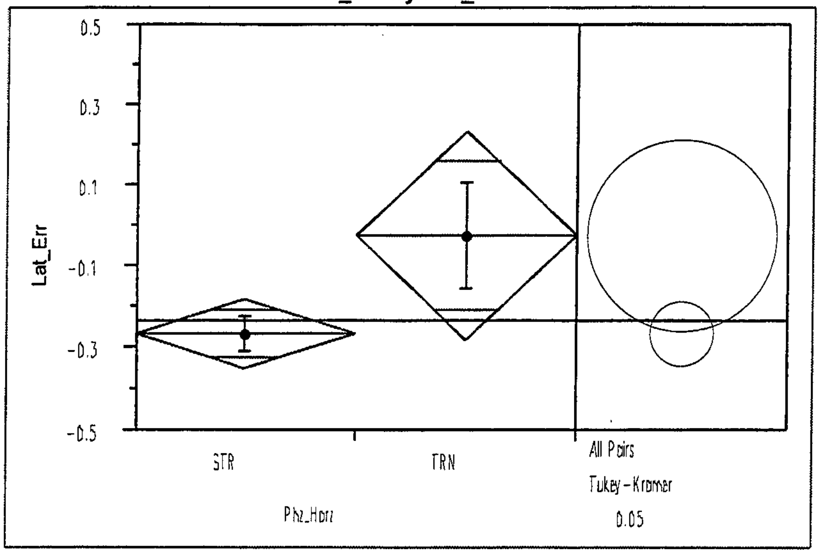
F Ratio	DF Num	DF Den	Prob>F
1.6650	1	2342.4	0.1971

t-Test

1.2904

Figure A.1- 117 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	16318	-0.2597	5.82078	0.04557
TRN	1892	-0.00098	5.77924	0.13286

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.258717
STR	-0.25872	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96010

Abs(Dif)-LSD	TRN	STR
TRN	-0.37067	-0.01817
STR	-0.01817	-0.12622

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	16318	5.820778	3.114442	3.078079
TRN	1892	5.779244	2.890671	2.890516

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0169	1	18208	0.8967
Brown-Forsythe	2.4318	1	18208	0.1189
Levene	3.4979	1	18208	0.0615
Bartlett	0.1731	1	?	0.6774

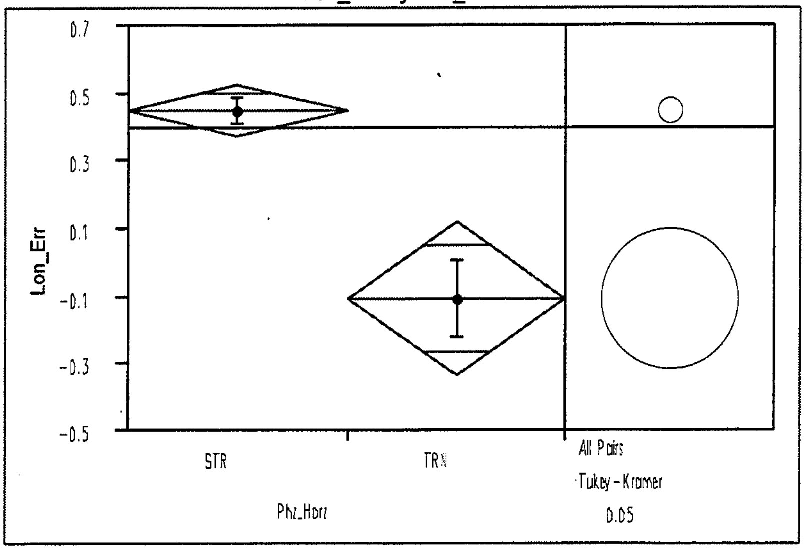
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.3926	1	2358.2	0.0656

t-Test
1.8419

Figure A.1- 118 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	16318	0.456530	5.07326	0.03971
TRN	1892	-0.08975	5.02537	0.11553

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.546280
TRN	-0.54628	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96010

Abs(Dif)-LSD	STR	TRN
STR	-0.10998	0.305012
TRN	0.305012	-0.32299

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	16318	5.073258	3.236401	3.231738
TRN	1892	5.025372	3.323618	3.323467

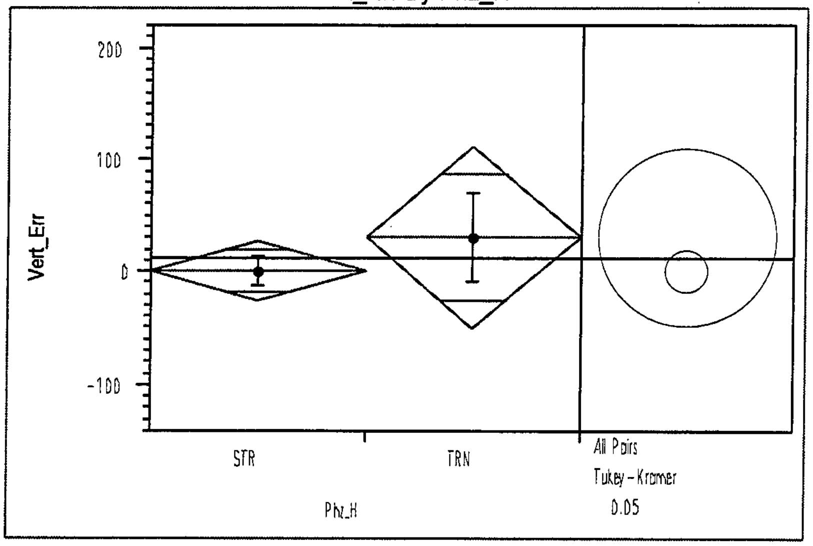
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0207	1	18208	0.8857
Brown-Forsythe	0.9378	1	18208	0.3329
Levene	0.8511	1	18208	0.3563
Bartlett	0.3032	1	?	0.5819

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
19.9945	1	2360.5	<.0001

t-Test
4.4715

Figure A.1- 119 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	16318	10.0765	1820.98	14.255
TRN	1892	39.1177	1808.85	41.586

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.0000	29.0413
STR	-29.0413	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96010

Abs(Dif)-LSD	TRN	STR
TRN	-115.968	-57.584
STR	-57.584	-39.488

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	16318	1820.979	777.3691	771.0343
TRN	1892	1808.851	800.4795	779.4070

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0157	1	18208	0.9002
Brown-Forsythe	0.0438	1	18208	0.8343
Levene	0.3350	1	18208	0.5628
Bartlett	0.1508	1	?	0.6978

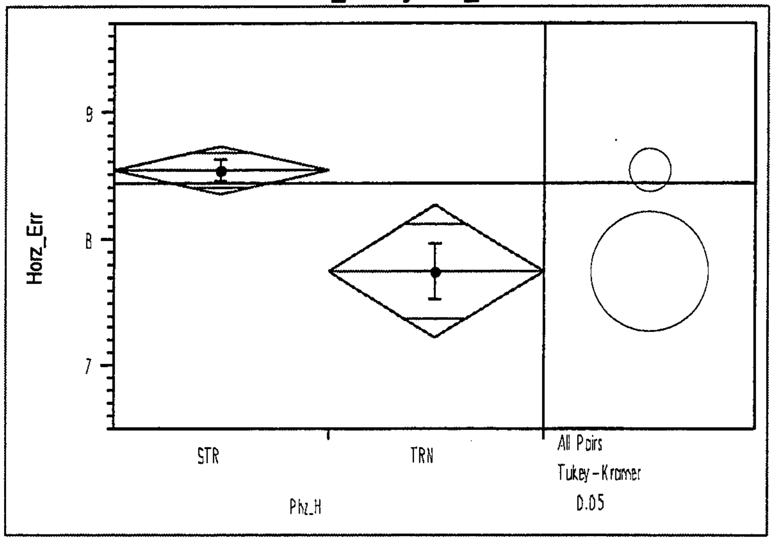
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.4364	1	2357.7	0.5089

t-Test
0.6606

Figure A.1- 120 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	9175	8.53584	9.51142	0.09930
TRN	1199	7.76842	7.64834	0.22088

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.767420
TRN	-0.76742	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96019

Abs(Dif)-LSD	STR	TRN
STR	-0.26959	0.206687
TRN	0.206687	-0.74576

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	9175	9.511425	6.109777	5.633776
TRN	1199	7.648342	5.397756	4.964420

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.2807	1	10372	0.0701
Brown-Forsythe	7.4841	1	10372	0.0062
Levene	10.6699	1	10372	0.0011
Bartlett	90.0718	1	?	<.0001

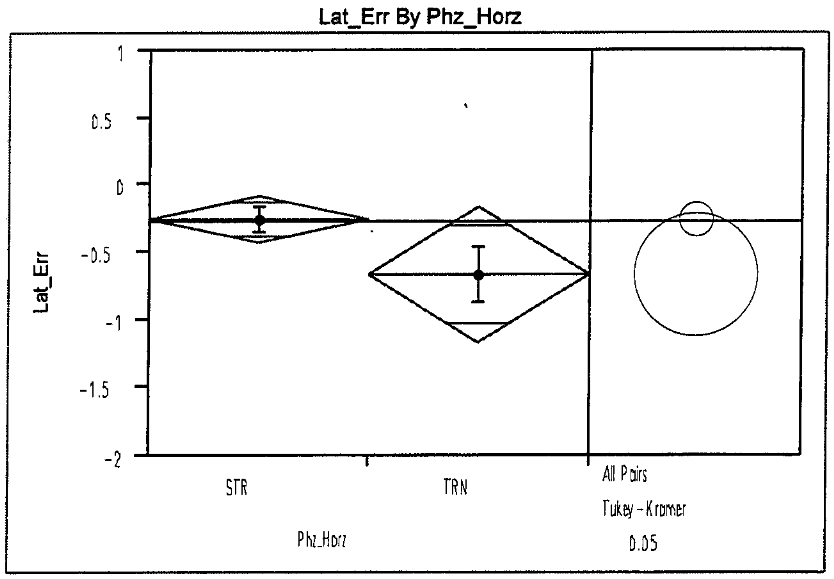
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
10.0417	1	1722	0.0016

t-Test

3.1689

Figure A.1- 121 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	9175	-0.21317	9.38578	0.09799
TRN	1199	-0.66354	7.40428	0.21383

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.450373
TRN	-0.45037	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96019

Abs(Dif)-LSD	STR	TRN
STR	-0.26564	-0.10214
TRN	-0.10214	-0.73483

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	9175	9.385777	4.743009	4.714468
TRN	1199	7.404276	3.825791	3.672525

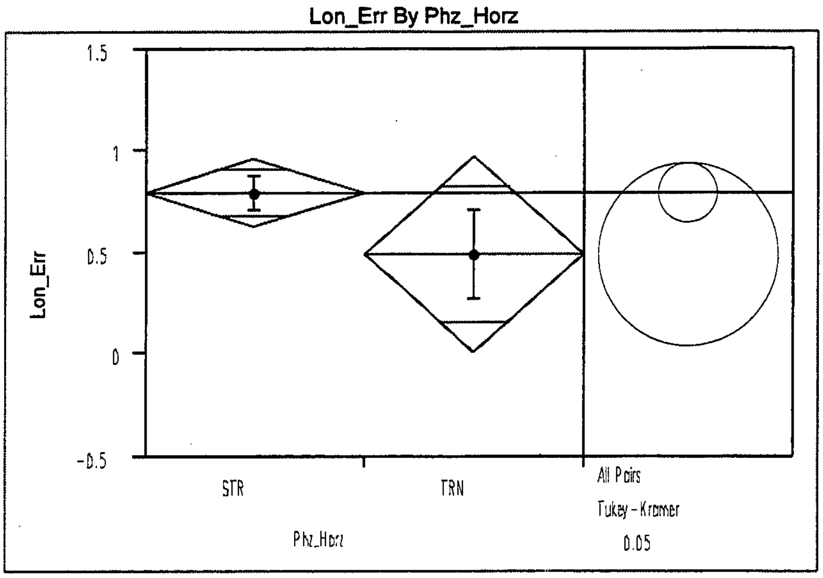
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	5.5623	1	10372	0.0184
Brown-Forsythe	18.2386	1	10372	<.0001
Levene	14.2379	1	10372	0.0002
Bartlett	105.5457	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.6662	1	1743.9	0.0557

t-Test
1.9147

Figure A.1- 122 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	9175	0.835531	8.63130	0.09011
TRN	1199	0.513125	7.96043	0.22989

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.322406
TRN	-0.32241	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96019

Abs(Dif)-LSD	STR	TRN
STR	-0.24763	-0.19265
TRN	-0.19265	-0.68502

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	9175	8.631296	5.547993	5.543110
TRN	1199	7.960427	5.580866	5.580622

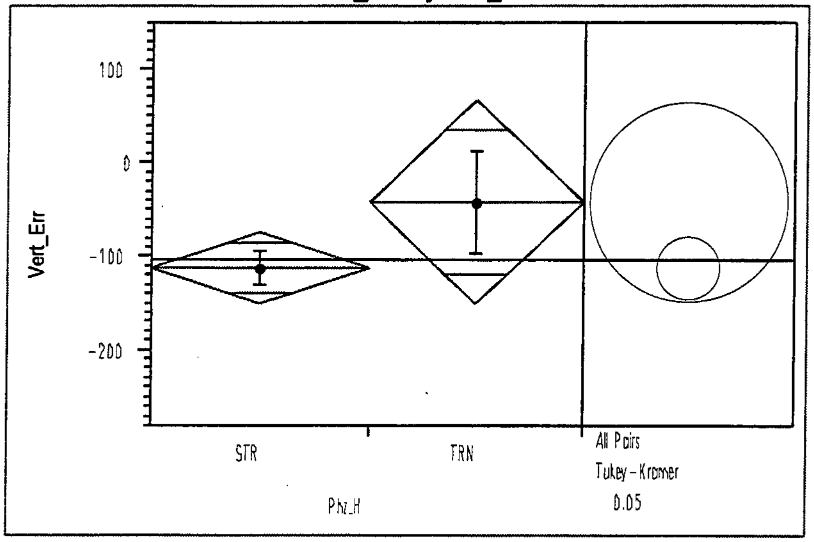
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.1268	1	10372	0.2885
Brown-Forsythe	0.0351	1	10372	0.8514
Levene	0.0270	1	10372	0.8694
Bartlett	13.3068	1	?	0.0003

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.7048	1	1589.5	0.1918
t-Test			
1.3057			

Figure A.1- 123 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	9175	-111.926	1930.07	20.150
TRN	1199	-35.298	1895.78	54.749

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.0000	76.6284
STR	-76.6284	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96019

Abs(Dif)-LSD	TRN	STR
TRN	-154.203	-39.315
STR	-39.315	-55.744

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

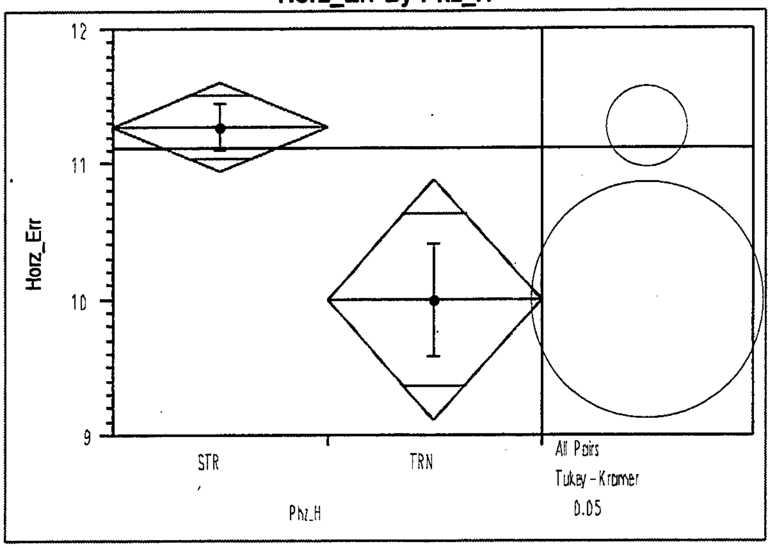
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	9175	1930.066	836.1124	771.1156
TRN	1199	1895.776	838.4980	819.3713

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0248	1	10372	0.8750
Brown-Forsythe	0.7920	1	10372	0.3735
Levene	0.0020	1	10372	0.9643
Bartlett	0.6746	1	?	0.4115

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.7253	1	1540.8	0.1892
t-Test			
1.3135			

Figure A.1- 124 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	4254	10.7846	11.7023	0.17942
TRN	637	9.5064	10.4089	0.41241

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.00000	1.27821
TRN	-1.27821	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96045

Abs(Dif)-LSD	STR	TRN
STR	-0.49064	0.31687
TRN	0.31687	-1.26792

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	4254	11.70232	7.510429	6.954786
TRN	637	10.40887	6.378097	5.888848

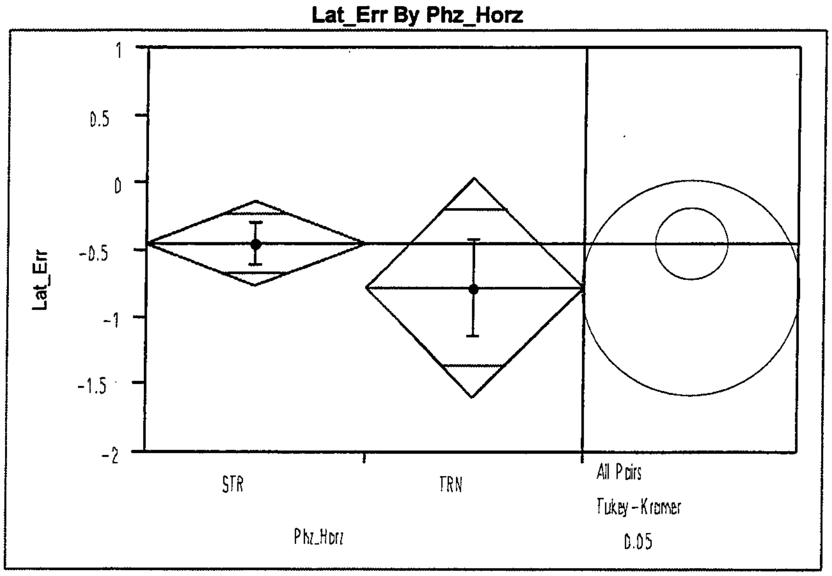
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.9388	1	4889	0.3326
Brown-Forsythe	6.4649	1	4889	0.0110
Levene	9.0099	1	4889	0.0027
Bartlett	14.3189	1	?	0.0002

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.0771	1	894.74	0.0046

t-Test
2.8420

Figure A.1- 125 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	4254	-0.40004	10.9280	0.16755
TRN	637	-0.73659	9.4788	0.37556

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.336548
TRN	-0.33655	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96045

Abs(Dif)-LSD	STR	TRN
STR	-0.45698	-0.55885
TRN	-0.55885	-1.18095

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	4254	10.92798	5.353029	5.267601
TRN	637	9.47882	4.043594	3.830462

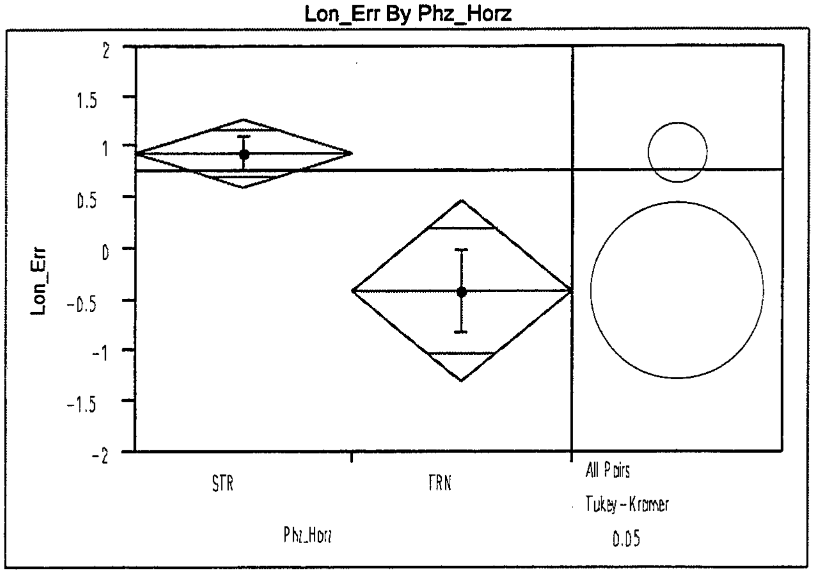
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.0814	1	4889	0.2984
Brown-Forsythe	12.7507	1	4889	0.0004
Levene	10.7328	1	4889	0.0011
Bartlett	20.8636	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.6697	1	908.97	0.4134

t-Test
0.8184

Figure A.1- 126 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	4254	0.951593	11.5236	0.17668
TRN	637	-0.39177	10.4074	0.41235

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.00000	1.34336
TRN	-1.34336	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96045

Abs(Dif)-LSD	STR	TRN
STR	-0.48394	0.39516
TRN	0.39516	-1.25060

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	4254	11.52359	7.627530	7.625923
TRN	637	10.40737	7.303754	7.303065

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.9631	1	4889	0.1612
Brown-Forsythe	0.8011	1	4889	0.3708
Levene	0.8063	1	4889	0.3693
Bartlett	10.9159	1	?	0.0010

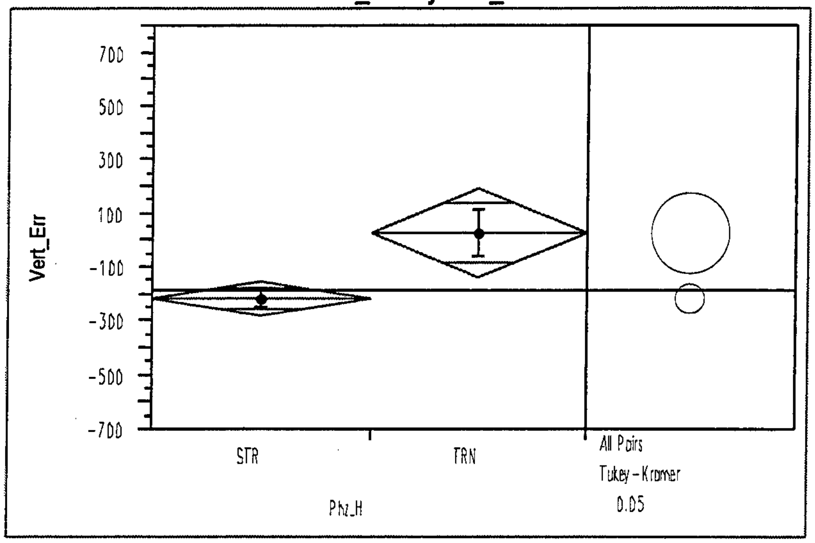
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.9670	1	886.49	0.0028

t-Test
2.9945

Figure A.1- 127 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Phz_H



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	4254	-210.646	2127.36	32.617
TRN	637	23.332	2234.08	88.517

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000	233.978
STR	-233.978	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96045

Abs(Dif)-LSD	TRN	STR
TRN	-235.249	55.611
STR	55.611	-91.033

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	4254	2127.360	1009.336	885.6140
TRN	637	2234.076	957.289	945.7591

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.1250	1	4889	0.7237
Brown-Forsythe	0.5238	1	4889	0.4692
Levene	0.4192	1	4889	0.5174
Bartlett	2.7141	1	?	0.0995

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.1517	1	818.18	0.0133

t-Test
2.4803

Figure A.1- 128 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

A.1.4 Vertical Phase of Flight Per Look Ahead Time

A.1.4.1 Summary Tables

Look Ahead Time	0			300		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	27915	4378	3635	24176	2150	3473
Avg. Horz. Error	1.19	1.21	1.35	2.95	4.71	3.71
Stddev. Horz. Error	1.04	0.88	1.51	3.25	3.9	3.76
Max. Horz. Error	42.39	11.19	16.91	84.31	50.76	63.15
Min. Horz. Error	0	0	0	0.01	0.02	0.02
Avg. Lat. Error	-0.02	-0.08	0.04	-0.09	-0.13	-0.13
Stddev. Lat. Error	1.29	1.28	1.76	3.51	4.44	3.96
Max. Lat. Error	32.23	8.32	11.67	65.49	38.93	22.62
Min. Lat. Error	-13.68	-5.18	-16	-39.47	-22.4	-36.24
Avg. Abs. Lat. Error	0.84	0.93	1.02	1.88	2.66	2.23
Stddev. Abs. Lat. Error	0.97	0.88	1.44	2.97	3.56	3.28
Max. Abs. Lat. Error	32.23	8.32	16	65.49	38.93	36.24
Min. Abs. Lat. Error	0	0	0	0	0	0
Avg. Long. Error	-0.02	0.07	-0.08	-0.01	1.45	-0.11
Stddev. Long. Error	0.91	0.77	1	2.62	3.94	3.49
Max. Long. Error	11.93	3.58	9.33	25.52	20.1	19.67
Min. Long. Error	-27.53	-11.19	-9.81	-65.39	-32.58	-63.13
Avg. Abs. Long. Error	0.61	0.54	0.65	1.71	3.09	2.33
Stddev. Abs. Long. Error	0.68	0.55	0.77	1.98	2.84	2.6
Max. Abs. Long. Error	27.53	11.19	9.81	65.39	32.58	63.13
Min. Abs. Long. Error	0	0	0	0	0	0
Avg. Vert. Error	43.04	143.42	-15.44	-22.97	996.7	-516.74
Stddev. Vert. Error	619.13	640.23	944.25	1140.53	2952.07	2644.55
Max. Vert. Error	36817	16745.34	7949	14714.2	14101	34817
Min. Vert. Error	-6824.15	-2010.37	-4734	-12244.5	-10885.8	-12626.9
Avg. Abs. Vert. Error	120.39	435.5	568.52	415.04	2271.07	2013.62
Stddev. Abs. Vert. Error	608.84	490.68	754.02	1062.58	2132.71	1790.23
Max. Abs. Vert. Error	36817	16745.34	7949	14714.2	14101	34817
Min. Abs. Vert. Error	0	0	0	0	0	0
Avg. Slant Range Error	1.19	1.21	1.36	2.95	4.75	3.76
Stddev. Slant Range Error	1.05	0.88	1.51	3.25	3.88	3.74
Max. Slant Range Error	42.39	11.52	16.91	84.34	50.76	63.15
Min. Slant Range Error	0	0	0	0.01	0.06	0.08

Figure A.1- 129 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	600			900		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	20064	818	3082	15766	230	2533
Avg. Horz. Error	4.86	8.45	5.82	6.61	13.56	7.54
Stddev. Horz. Error	5.34	6.42	5.63	7.23	10.25	6.91
Max. Horz. Error	125.68	38.68	73.81	167.79	76.9	92.08
Min. Horz. Error	0.02	0.04	0.04	0.02	0.23	0.06
Avg. Lat. Error	-0.21	0.25	-0.03	-0.27	0.5	0.09
Stddev. Lat. Error	5.41	6.76	5.19	7.03	8.87	6.47
Max. Lat. Error	97.45	29.34	34.75	129.48	43.07	64.16
Min. Lat. Error	-61.74	-28.48	-37.37	-94.55	-27.26	-43.4
Avg. Abs. Lat. Error	2.8	4.02	2.97	3.56	5.24	3.61
Stddev. Abs. Lat. Error	4.63	5.43	4.25	6.06	7.17	5.37
Max. Abs. Lat. Error	97.45	29.34	37.37	129.48	43.07	64.16
Min. Abs. Lat. Error	0	0	0	0	0.01	0
Avg. Long. Error	0.2	4.1	0.45	0.43	7.06	0.51
Stddev. Long. Error	4.78	7.08	6.2	6.81	12.68	7.91
Max. Long. Error	91.73	31.85	73.8	94.25	39.37	66.05
Min. Long. Error	-79.36	-32.6	-42.72	-106.71	-76.71	-59.55
Avg. Abs. Long. Error	3.07	6.18	4.07	4.37	10.74	5.45
Stddev. Abs. Long. Error	3.67	5.37	4.69	5.24	9.75	5.75
Max. Abs. Long. Error	91.73	32.6	73.8	106.71	76.71	66.05
Min. Abs. Long. Error	0	0.01	0	0	0.07	0
Avg. Vert. Error	-93.56	1322.7	-726.17	-120.46	810.29	-666.06
Stddev. Vert. Error	1551.14	3799.44	3080.04	1721.64	3518.2	3089.16
Max. Vert. Error	20728.9	20033	28933	30746.5	20083	22083
Min. Vert. Error	-15373.8	-9233	-14433.7	-16419.3	-6400	-15260.4
Avg. Abs. Vert. Error	610.27	2963.65	2377.63	691.68	2700.92	2367.68
Stddev. Abs. Vert. Error	1429.11	2719.09	2087.87	1581.17	2389.62	2092.51
Max. Abs. Vert. Error	20728.9	20033	28933	30746.5	20083	22083
Min. Abs. Vert. Error	0	0	0	0	16.39	0
Avg. Slant Range Error	4.87	8.49	5.86	6.62	13.58	7.58
Stddev. Slant Range Error	5.34	6.4	5.61	7.23	10.24	6.89
Max. Slant Range Error	125.72	38.68	73.82	167.86	76.9	92.08
Min. Slant Range Error	0.02	0.17	0.15	0.03	0.29	0.11

Figure A.1- 130 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1200			1500		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	11878	67	1891	8394	22	1262
Avg. Horz. Error	8.14	15.88	8.65	9.33	13.14	9.47
Stddev. Horz. Error	9	13.46	7.81	10.22	12.97	9.13
Max. Horz. Error	173.62	62.8	68.48	156.35	50.19	72.96
Min. Horz. Error	0.02	0.72	0.04	0.01	3.11	0.11
Avg. Lat. Error	-0.32	0.62	0.41	-0.42	-3.78	1
Stddev. Lat. Error	8.6	9.9	6.98	9.63	13.25	8.33
Max. Lat. Error	134.87	29.67	53.61	120.34	16.99	65.64
Min. Lat. Error	-124.94	-46.11	-66.12	-143.49	-40.37	-70.8
Avg. Abs. Lat. Error	4.2	5.21	3.85	4.6	7.16	4.37
Stddev. Abs. Lat. Error	7.51	8.42	5.84	8.47	11.69	7.16
Max. Abs. Lat. Error	134.87	46.11	66.12	143.49	40.37	70.8
Min. Abs. Lat. Error	0	0.02	0	0	0.03	0
Avg. Long. Error	0.56	6.09	1.33	0.68	2.87	1.48
Stddev. Long. Error	8.53	17.36	9.23	9.91	12.25	10.02
Max. Long. Error	96.16	39.2	48.6	97.63	27.67	44.17
Min. Long. Error	-109.33	-62.47	-60.41	-99.82	-32.7	-56.49
Avg. Abs. Long. Error	5.56	13.48	6.52	6.59	9.14	6.95
Stddev. Abs. Long. Error	6.5	12.42	6.66	7.44	8.45	7.37
Max. Abs. Long. Error	109.33	62.47	60.41	99.82	32.7	56.49
Min. Abs. Long. Error	0	0.52	0	0	0.51	0.01
Avg. Vert. Error	-125.54	366.59	-692.95	-167.37	1720.92	-1015.01
Stddev. Vert. Error	1861.58	3022.95	3212.21	1966.21	5173.23	3302.33
Max. Vert. Error	37473.73	15524.09	15561.15	38907.87	20104.51	11333
Min. Vert. Error	-15900	-5733	-13410.8	-15900	-2899	-17219.3
Avg. Abs. Vert. Error	744.35	1904.83	2500.94	822	2641.13	2658.72
Stddev. Abs. Vert. Error	1710.89	2364.59	2130.9	1793.94	4749.44	2205
Max. Abs. Vert. Error	37473.73	15524.09	15561.15	38907.87	20104.51	17219.3
Min. Abs. Vert. Error	0	0	0	0	182.91	0
Avg. Slant Range Error	8.15	15.89	8.69	9.34	13.16	9.51
Stddev. Slant Range Error	8.99	13.46	7.79	10.22	12.98	9.11
Max. Slant Range Error	173.7	62.8	68.48	156.48	50.3	72.96
Min. Slant Range Error	0.02	0.77	0.15	0.01	3.11	0.16

Figure A.1- 131 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1800		
Vertical Phase of Flight	Level	Ascent	Descent
Sample Quantity	5652	11	781
Avg. Horz. Error	10.23	8.6	9.71
Stddev. Horz. Error	11.1	5.07	9.34
Max. Horz. Error	169.84	20.52	72.73
Min. Horz. Error	0.04	3.89	0.19
Avg. Lat. Error	-0.45	-0.67	1.44
Stddev. Lat. Error	10.24	4.54	8.53
Max. Lat. Error	117.09	5.05	72.43
Min. Lat. Error	-155.99	-13.55	-30.86
Avg. Abs. Lat. Error	4.8	1.99	4.35
Stddev. Abs. Lat. Error	9.05	4.09	7.48
Max. Abs. Lat. Error	155.99	13.55	72.43
Min. Abs. Lat. Error	0	0.07	0
Avg. Long. Error	0.79	-2.91	1.57
Stddev. Long. Error	11.06	8.75	10.22
Max. Long. Error	98.01	7.18	41.28
Min. Long. Error	-78.53	-20.51	-62.08
Avg. Abs. Long. Error	7.44	7.64	7.31
Stddev. Abs. Long. Error	8.23	4.66	7.3
Max. Abs. Long. Error	98.01	20.51	62.08
Min. Abs. Long. Error	0	2.78	0
Avg. Vert. Error	-220.69	2367.53	-1135.5
Stddev. Vert. Error	2072.25	4803.94	3374.12
Max. Vert. Error	31668.16	16540.79	11033
Min. Vert. Error	-15800	-200	-12044.6
Avg. Abs. Vert. Error	868.83	2403.89	2750.38
Stddev. Abs. Vert. Error	1894.19	4784.03	2258.63
Max. Abs. Vert. Error	31668.16	16540.79	12044.58
Min. Abs. Vert. Error	0	0	3.91
Avg. Slant Range Error	10.24	8.62	9.75
Stddev. Slant Range Error	11.1	5.1	9.32
Max. Slant Range Error	169.84	20.52	72.73
Min. Slant Range Error	0.04	3.89	0.37

Figure A.1- 132 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	0			300		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	21791	2345	2012	18964	1673	1863
Avg. Horz. Error	1.14	1.15	1.04	3	4.78	3.54
Stddev. Horz. Error	0.96	0.87	0.78	3.42	3.98	4
Max. Horz. Error	42.39	11.19	4.68	84.31	50.76	63.15
Min. Horz. Error	0	0	0	0.01	0.02	0.02
Avg. Lat. Error	-0.02	-0.08	0	-0.11	-0.13	-0.29
Stddev. Lat. Error	1.21	1.21	1.11	3.7	4.52	4.1
Max. Lat. Error	32.23	8.32	4.27	65.49	38.93	19.22
Min. Lat. Error	-6.04	-5.18	-4.5	-39.47	-22.4	-36.24
Avg. Abs. Lat. Error	0.8	0.86	0.75	1.95	2.6	2.21
Stddev. Abs. Lat. Error	0.9	0.86	0.82	3.15	3.69	3.47
Max. Abs. Lat. Error	32.23	8.32	4.5	65.49	38.93	36.24
Min. Abs. Lat. Error	0	0	0	0	0	0
Avg. Long. Error	-0.03	0.09	-0.05	0	1.72	0
Stddev. Long. Error	0.88	0.77	0.68	2.64	3.92	3.41
Max. Long. Error	11.93	3.58	2.53	25.52	20.1	19.67
Min. Long. Error	-27.53	-11.19	-2.81	-65.39	-32.58	-63.13
Avg. Abs. Long. Error	0.6	0.55	0.53	1.7	3.21	2.13
Stddev. Abs. Long. Error	0.65	0.54	0.44	2.02	2.83	2.66
Max. Abs. Long. Error	27.53	11.19	2.81	65.39	32.58	63.13
Min. Abs. Long. Error	0	0	0	0	0	0
Avg. Vert. Error	33.86	164.9	-54.94	-0.98	926.65	-102.63
Stddev. Vert. Error	582.1	689.82	548.35	1028.54	2786.63	2659.6
Max. Vert. Error	36817	16745.34	1699.79	14714.2	14101	34817
Min. Vert. Error	-2800	-1515.37	-2264.79	-8000	-10304.6	-9892.71
Avg. Abs. Vert. Error	79.21	436.46	412.27	334.12	2073.49	1944.84
Stddev. Abs. Vert. Error	577.68	558.99	365.59	972.76	2079.08	1816.48
Max. Abs. Vert. Error	36817	16745.34	2264.79	14714.2	14101	34817
Min. Abs. Vert. Error	0	0	0	0	0	0
Avg. Slant Range Error	1.15	1.16	1.05	3.01	4.82	3.6
Stddev. Slant Range Error	0.97	0.87	0.78	3.41	3.97	3.97
Max. Slant Range Error	42.39	11.52	4.69	84.34	50.76	63.15
Min. Slant Range Error	0	0	0	0.01	0.06	0.08

Figure A.1- 133 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	600			900		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	15821	790	1599	12478	224	1270
Avg. Horz. Error	5.01	8.5	5.64	6.83	13.62	7.33
Stddev. Horz. Error	5.61	6.36	5.71	7.57	9.98	7.46
Max. Horz. Error	125.68	38.68	51.38	167.79	76.9	92.08
Min. Horz. Error	0.02	0.04	0.04	0.03	0.23	0.06
Avg. Lat. Error	-0.26	0.23	-0.19	-0.34	0.44	0.24
Stddev. Lat. Error	5.77	6.74	5.74	7.57	8.98	7.44
Max. Lat. Error	97.45	29.34	34.75	129.48	43.07	64.16
Min. Lat. Error	-61.74	-28.48	-37.37	-94.55	-27.26	-43.4
Avg. Abs. Lat. Error	3	4.01	3.17	3.87	5.31	4.07
Stddev. Abs. Lat. Error	4.94	5.42	4.78	6.51	7.25	6.23
Max. Abs. Lat. Error	97.45	29.34	37.37	129.48	43.07	64.16
Min. Abs. Lat. Error	0	0	0	0	0.01	0
Avg. Long. Error	0.22	4.27	0.28	0.45	7.49	0.28
Stddev. Long. Error	4.82	7.01	5.61	6.81	12.2	7.35
Max. Long. Error	91.73	31.85	25.54	94.25	39.37	66.05
Min. Long. Error	-79.36	-22.09	-35.26	-106.71	-76.71	-59.55
Avg. Abs. Long. Error	3.05	6.25	3.7	4.35	10.76	4.75
Stddev. Abs. Long. Error	3.73	5.32	4.22	5.26	9.43	5.61
Max. Abs. Long. Error	91.73	31.85	35.26	106.71	76.71	66.05
Min. Abs. Long. Error	0	0.01	0	0	0.07	0
Avg. Vert. Error	-20.23	1329.85	-307.77	-29.38	840.91	-329.29
Stddev. Vert. Error	1426.57	3826.34	3063.43	1594.72	3546.01	3215.15
Max. Vert. Error	20728.9	20033	28933	30746.5	20083	22083
Min. Vert. Error	-10000	-9233	-10552	-10700	-6400	-9797.11
Avg. Abs. Vert. Error	507.3	2980.59	2298.72	579.34	2736.66	2396.95
Stddev. Abs. Vert. Error	1333.46	2741.62	2047.42	1486.05	2400.32	2166.98
Max. Abs. Vert. Error	20728.9	20033	28933	30746.5	20083	22083
Min. Abs. Vert. Error	0	0	0	0	16.39	0
Avg. Slant Range Error	5.02	8.54	5.69	6.84	13.64	7.38
Stddev. Slant Range Error	5.61	6.34	5.68	7.56	9.97	7.44
Max. Slant Range Error	125.72	38.68	51.38	167.86	76.9	92.08
Min. Slant Range Error	0.02	0.29	0.15	0.03	0.29	0.11

Figure A.1- 134 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

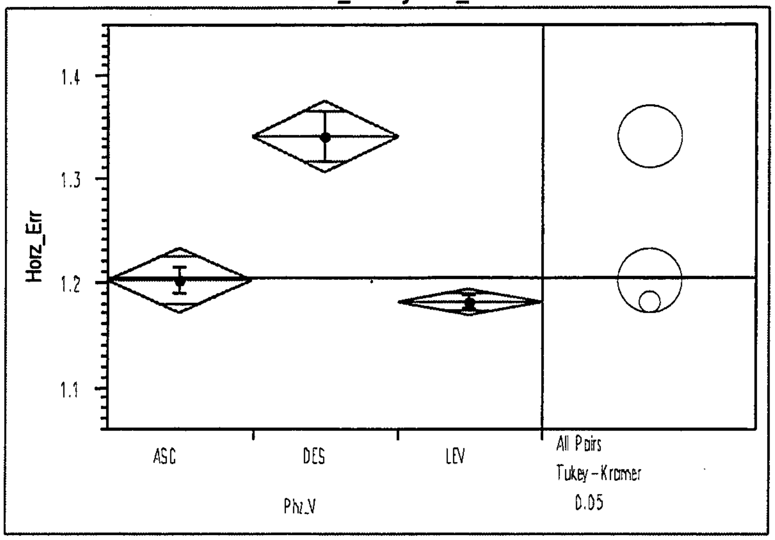
Look Ahead Time	1200			1500		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	9360	60	954	6627	20	660
Avg. Horz. Error	8.43	15.11	8.16	9.71	13.99	8.85
Stddev. Horz. Error	9.41	11.15	8.11	10.76	13.33	9.05
Max. Horz. Error	173.62	49.91	68.48	156.35	50.19	72.96
Min. Horz. Error	0.02	0.72	0.04	0.01	3.11	0.11
Avg. Lat. Error	-0.36	0.54	0.64	-0.52	-4.56	1.15
Stddev. Lat. Error	9.29	10.37	7.86	10.37	13.67	8.62
Max. Lat. Error	134.87	29.67	53.61	120.34	16.99	65.64
Min. Lat. Error	-124.94	-46.11	-66.12	-143.49	-40.37	-70.8
Avg. Abs. Lat. Error	4.62	5.41	4.28	5.02	7.47	4.51
Stddev. Abs. Lat. Error	8.07	8.83	6.62	9.09	12.25	7.43
Max. Abs. Lat. Error	134.87	46.11	66.12	143.49	40.37	70.8
Min. Abs. Lat. Error	0	0.02	0	0	0.03	0
Avg. Long. Error	0.7	8.99	1.25	0.8	3.38	1.48
Stddev. Long. Error	8.52	12.91	8.29	10.08	12.77	9.09
Max. Long. Error	96.16	39.2	39.23	97.63	27.67	44.17
Min. Long. Error	-109.33	-19.1	-60.41	-99.82	-32.7	-56.49
Avg. Abs. Long. Error	5.52	12.59	5.57	6.66	9.83	6.14
Stddev. Abs. Long. Error	6.53	9.36	6.26	7.61	8.56	6.85
Max. Abs. Long. Error	109.33	39.2	60.41	99.82	32.7	56.49
Min. Abs. Long. Error	0	0.52	0	0	0.51	0.03
Avg. Vert. Error	-57.6	393.25	-580.42	-103.97	1828.02	-883.58
Stddev. Vert. Error	1735.54	3155.29	3150.19	1829.04	5424.51	3239.87
Max. Vert. Error	37473.73	15524.09	15561.15	38907.87	20104.51	11333
Min. Vert. Error	-8230.95	-5733	-10485.7	-8330.24	-2899	-9483.61
Avg. Abs. Vert. Error	603.38	1986.48	2401	663.35	2840.24	2547.37
Stddev. Abs. Vert. Error	1628.28	2469.84	2118.99	1707.66	4944.82	2186.27
Max. Abs. Vert. Error	37473.73	15524.09	15561.15	38907.87	20104.51	11333
Min. Abs. Vert. Error	0	0	0	0	182.91	0
Avg. Slant Range Error	8.44	15.13	8.2	9.72	14.02	8.89
Stddev. Slant Range Error	9.4	11.14	8.08	10.76	13.33	9.02
Max. Slant Range Error	173.7	49.91	68.48	156.48	50.3	72.96
Min. Slant Range Error	0.02	0.77	0.15	0.01	3.11	0.3

Figure A.1- 135 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	1800		
Vertical Phase of Flight	Level	Ascent	Descent
Sample Quantity	4446	10	435
Avg. Horz. Error	10.81	8.88	8.69
Stddev. Horz. Error	11.8	5.25	8.45
Max. Horz. Error	169.84	20.52	62.23
Min. Horz. Error	0.04	3.89	0.19
Avg. Lat. Error	-0.6	-1.24	1.16
Stddev. Lat. Error	11.01	4.35	7.53
Max. Lat. Error	117.09	0.75	53.61
Min. Lat. Error	-155.99	-13.55	-30.86
Avg. Abs. Lat. Error	5.21	1.69	3.84
Stddev. Abs. Lat. Error	9.72	4.18	6.58
Max. Abs. Lat. Error	155.99	13.55	53.61
Min. Abs. Lat. Error	0	0.07	0
Avg. Long. Error	0.81	-2.93	0.55
Stddev. Long. Error	11.57	9.22	9.42
Max. Long. Error	98.01	7.18	41.28
Min. Long. Error	-78.53	-20.51	-62.08
Avg. Abs. Long. Error	7.73	8.12	6.44
Stddev. Abs. Long. Error	8.65	4.61	6.89
Max. Abs. Long. Error	98.01	20.51	62.08
Min. Abs. Long. Error	0	3.88	0
Avg. Vert. Error	-116.41	2414.28	-891.51
Stddev. Vert. Error	1966.69	5061.16	3299.07
Max. Vert. Error	31668.16	16540.79	11033
Min. Vert. Error	-8050.02	-200	-10550
Avg. Abs. Vert. Error	721.23	2454.28	2617.76
Stddev. Abs. Vert. Error	1833.34	5039.74	2193.63
Max. Abs. Vert. Error	31668.16	16540.79	11033
Min. Abs. Vert. Error	0	0	3.91
Avg. Slant Range Error	10.82	8.91	8.73
Stddev. Slant Range Error	11.8	5.28	8.43
Max. Slant Range Error	169.84	20.52	62.25
Min. Slant Range Error	0.04	3.89	0.37

Figure A.1- 136 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

A.1.4.2 Statistical Tests



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4378	1.20749	0.88352	0.01335
DES	3635	1.34907	1.51234	0.02508
LEV	27915	1.18559	1.04348	0.00625

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	ASC	LEV
DES	0.000000	0.141582	0.163481
ASC	-0.14158	0.000000	0.021898
LEV	-0.16348	-0.0219	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34380

Abs(Dif)-LSD	DES	ASC	LEV
DES	-0.05953	0.084634	0.118729
ASC	0.084634	-0.05424	-0.01936
LEV	0.118729	-0.01936	-0.02148

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4378	0.883522	0.6833410	0.6684961
DES	3635	1.512336	0.9413354	0.8655014
LEV	27915	1.043477	0.6898680	0.6641586

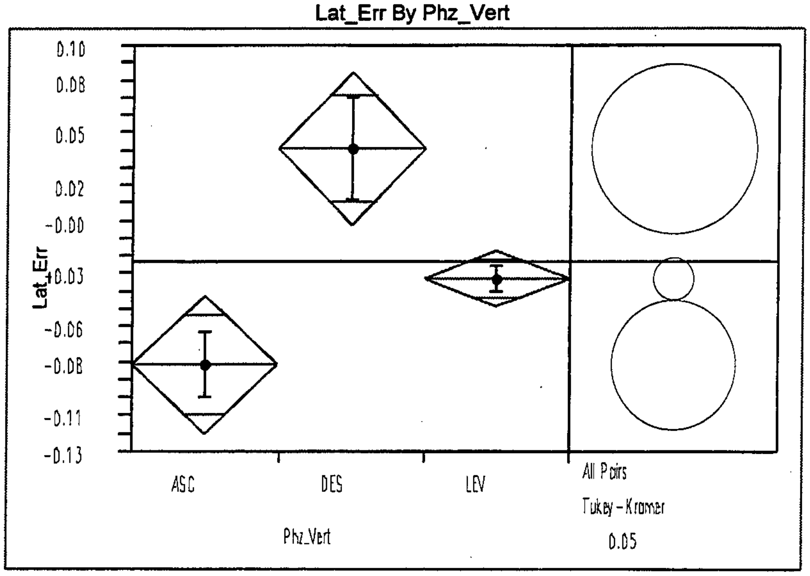
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	21.7535	2	35925	<.0001
Brown-Forsythe	86.2379	2	35925	<.0001
Levene	158.6746	2	35925	<.0001
Bartlett	709.3944	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
20.3511	2	6536.1	<.0001

Figure A.1- 137 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4378	-0.07751	1.27855	0.01932
DES	3635	0.042201	1.76059	0.02920
LEV	27915	-0.02281	1.28779	0.00771

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	LEV	ASC
DES	0.000000	0.065006	0.119712
LEV	-0.06501	0.000000	0.054706
ASC	-0.11971	-0.05471	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34380

Abs(Dif)-LSD	DES	LEV	ASC
DES	-0.07379	0.009539	0.049126
LEV	0.009539	-0.02663	0.003572
ASC	0.049126	0.003572	-0.06723

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

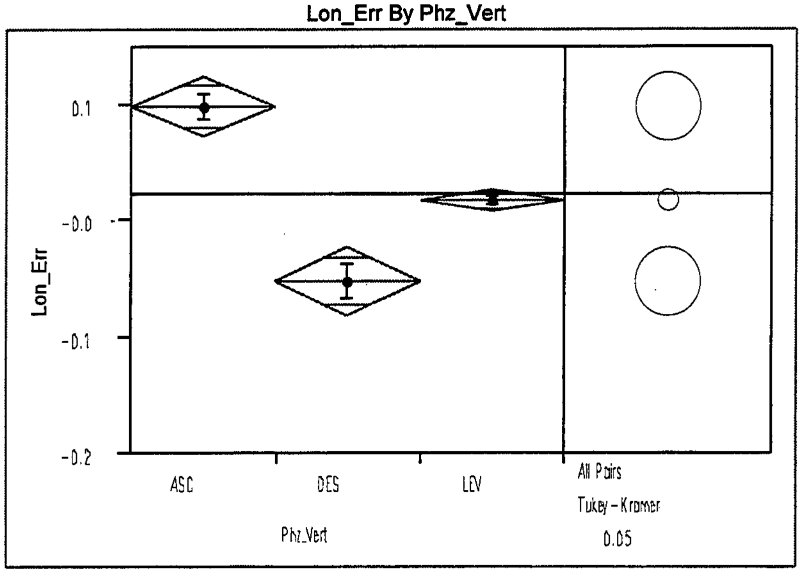
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4378	1.278546	0.931243	0.930869
DES	3635	1.760591	1.017777	1.016730
LEV	27915	1.287788	0.842900	0.842389

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	51.1363	2	35925	<.0001
Brown-Forsythe	55.6273	2	35925	<.0001
Levene	55.9512	2	35925	<.0001
Bartlett	379.7888	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.3653	2	6360.8	0.0017

Figure A.1- 138 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4378	0.067060	0.770570	0.01165
DES	3635	-0.08469	0.999504	0.01658
LEV	27915	-0.02002	0.913888	0.00547

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000000	0.087080	0.151751
LEV	-0.08708	0.000000	0.064671
DES	-0.15175	-0.06467	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34380

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.04543	0.052530	0.104058
LEV	0.052530	-0.01799	0.027193
DES	0.104058	0.027193	-0.04986

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4378	0.7705700	0.5427742	0.5422585
DES	3635	0.9995036	0.6452671	0.6443120
LEV	27915	0.9138881	0.6131749	0.6131590

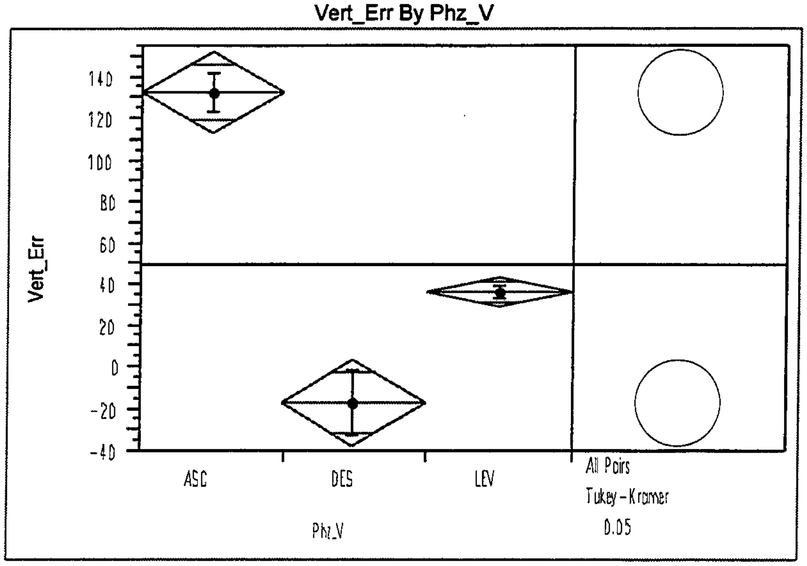
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.6313	2	35925	0.0097
Brown-Forsythe	27.0145	2	35925	<.0001
Levene	27.0044	2	35925	<.0001
Bartlett	142.8342	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
33.6990	2	6783.8	<.0001

Figure A.1- 139 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Vert_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4378	143.422	640.230	9.676
DES	3635	-15.436	944.248	15.662
LEV	27915	43.041	619.130	3.706

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000	100.381	158.857
LEV	-100.381	0.000	58.476
DES	-158.857	-58.476	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34380

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-33.153	75.167	124.051
LEV	75.167	-13.129	31.125
DES	124.051	31.125	-36.384

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4378	640.2296	430.7715	428.1537
DES	3635	944.2478	567.4349	566.3651
LEV	27915	619.1305	147.9035	120.3874

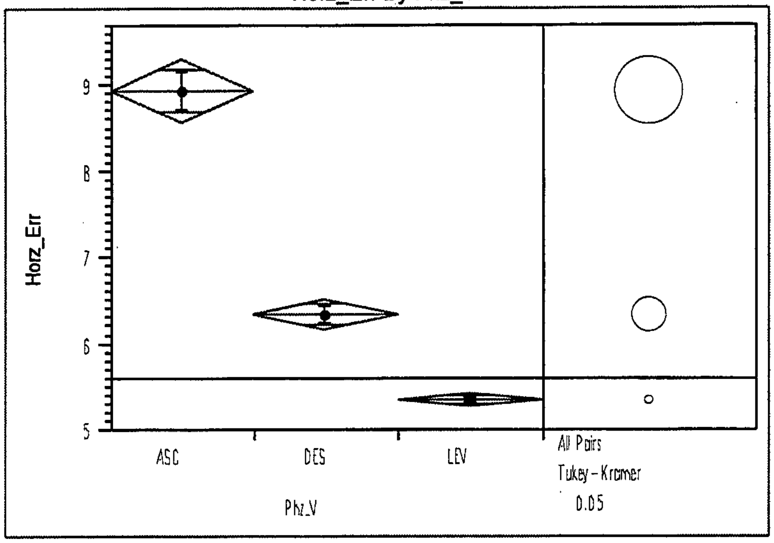
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.6011	2	35925	0.0273
Brown-Forsythe	1193.4789	2	35925	0.0000
Levene	1062.8404	2	35925	0.0000
Bartlett	713.5924	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
56.8077	2	6240.5	<.0001

Figure A.1- 140 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	818	8.44954	6.42419	0.22462
DES	3082	5.81711	5.62843	0.10138
LEV	20064	4.86284	5.34377	0.03773

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	2.63244	3.58670
DES	-2.63244	0.00000	0.95427
LEV	-3.58670	-0.95427	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34385

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.62831	2.13266	3.13345
DES	2.13266	-0.32369	0.70843
LEV	3.13345	0.70843	-0.12687

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	818	6.424191	5.046806	4.877465
DES	3082	5.628426	3.789303	3.578561
LEV	20064	5.343766	3.517124	3.210825

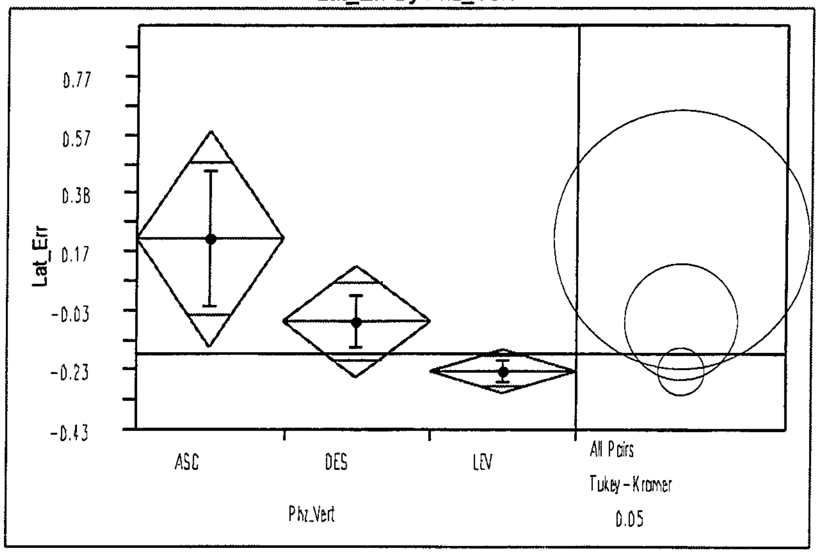
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.0840	2	23961	0.1245
Brown-Forsythe	57.8195	2	23961	<.0001
Levene	60.0652	2	23961	<.0001
Bartlett	34.9995	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
155.3402	2	1879.7	<.0001

Figure A.1- 141 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	818	0.248885	6.75532	0.23619
DES	3082	-0.03138	5.18980	0.09348
LEV	20064	-0.20943	5.40798	0.03818

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.000000	0.280265	0.458314
DES	-0.28027	0.000000	0.178049
LEV	-0.45831	-0.17805	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34385

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.62956	-0.2205	0.004166
DES	-0.2205	-0.32434	-0.06828
LEV	0.004166	-0.06828	-0.12712

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

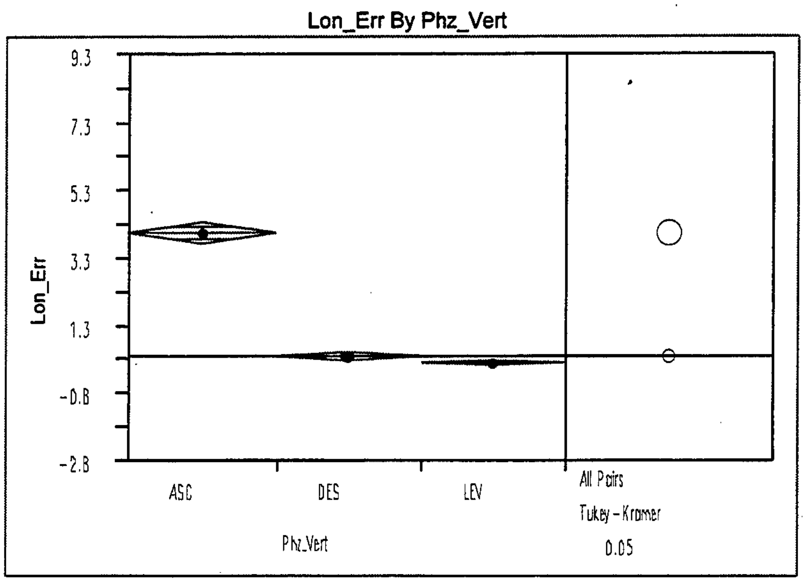
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	818	6.755321	4.029199	4.016305
DES	3082	5.189798	2.973750	2.972403
LEV	20064	5.407984	2.824707	2.800483

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.3448	2	23961	0.0018
Brown-Forsythe	28.2611	2	23961	<.0001
Levene	27.6353	2	23961	<.0001
Bartlett	51.7520	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.1959	2	1888	0.0412

Figure A.1- 142 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	818	4.10383	7.08477	0.24771
DES	3082	0.45041	6.19604	0.11161
LEV	20064	0.19525	4.78288	0.03377

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	3.65342	3.90858
DES	-3.65342	0.00000	0.25516
LEV	-3.90858	-0.25516	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34385

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.58871	3.18515	3.48390
DES	3.18515	-0.30329	0.02482
LEV	3.48390	0.02482	-0.11887

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	818	7.084766	5.387357	5.355981
DES	3082	6.196044	4.048005	4.047764
LEV	20064	4.782883	3.069458	3.069352

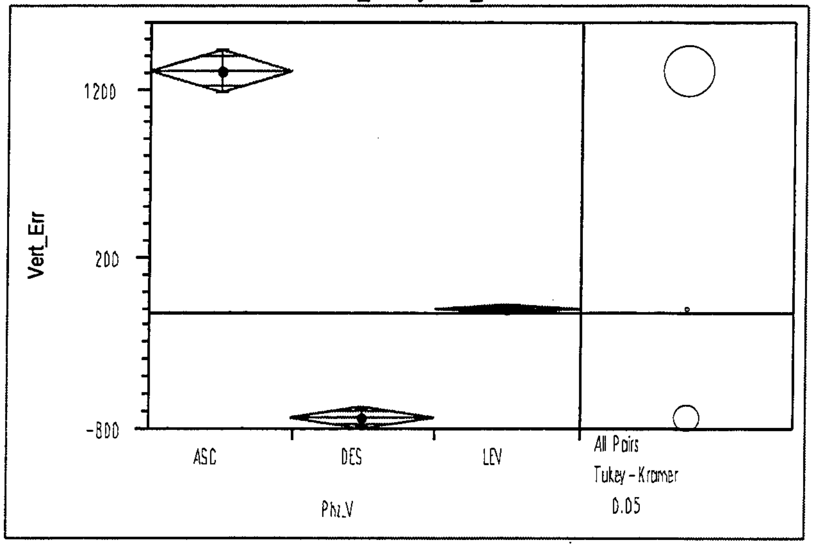
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	30.1699	2	23961	<.0001
Brown-Forsythe	209.9188	2	23961	<.0001
Levene	213.9512	2	23961	<.0001
Bartlett	323.5669	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
123.4125	2	1830.1	<.0001

Figure A.1- 143 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Vert_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	818	1322.70	3799.44	132.84
DES	3082	-726.17	3080.04	55.48
LEV	20064	-93.56	1551.14	10.95

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	1416.26	2048.87
LEV	-1416.26	0.00	632.61
DES	-2048.87	-632.61	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34385

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-223.73	1254.87	1870.91
LEV	1254.87	-45.17	545.07
DES	1870.91	545.07	-115.26

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	818	3799.441	2867.027	2854.848
DES	3082	3080.038	2267.361	2267.097
LEV	20064	1551.141	666.359	610.266

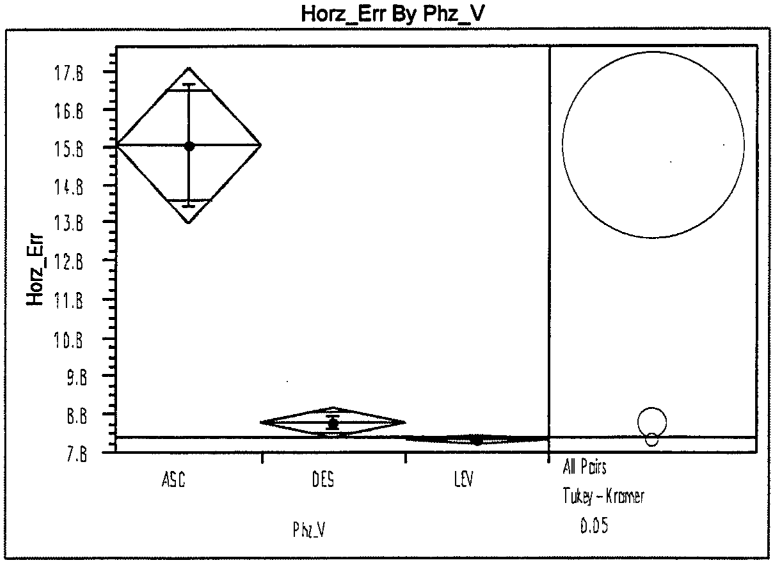
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	615.3838	2	23961	<.0001
Brown-Forsythe	2125.5093	2	23961	0.0000
Levene	2065.6608	2	23961	0.0000
Bartlett	2395.9045	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
120.8911	2	1767.1	<.0001

Figure A.1- 144 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	67	15.8809	13.4629	1.6448
DES	1891	8.6502	7.8128	0.1797
LEV	11878	8.1401	8.9953	0.0825

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	7.23073	7.74086
DES	-7.23073	0.00000	0.51013
LEV	-7.74086	-0.51013	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34395

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-3.59216	4.64608	5.19366
DES	4.64608	-0.67616	-0.00464
LEV	5.19366	-0.00464	-0.26979

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

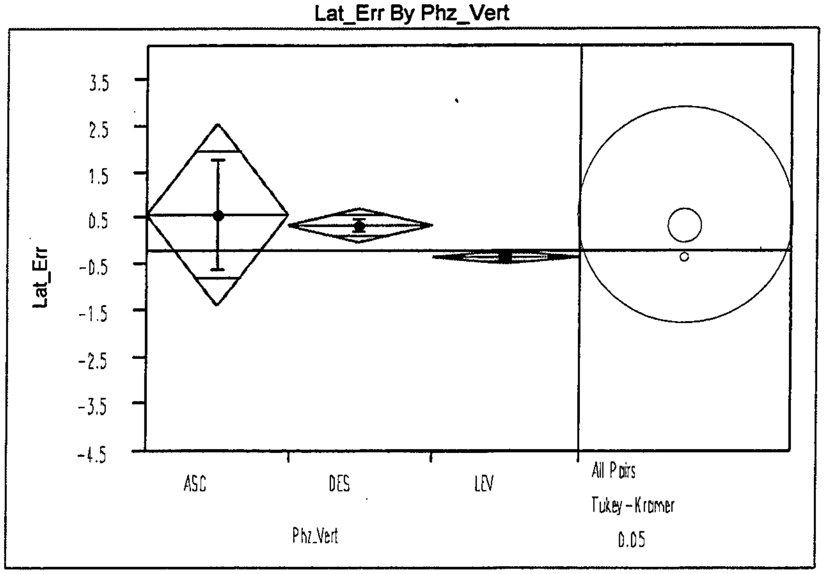
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	67	13.46293	10.10981	9.784099
DES	1891	7.81284	5.60207	5.337903
LEV	11878	8.99532	5.80692	5.348561

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.6157	2	13833	0.0732
Brown-Forsythe	11.6325	2	13833	<.0001
Levene	14.6769	2	13833	<.0001
Bartlett	45.7431	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.0737	2	172.57	<.0001

Figure A.1- 145 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	67	0.623984	9.90257	1.2098
DES	1891	0.412936	6.98297	0.1606
LEV	11878	-0.31722	8.59878	0.0789

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.000000	0.211047	0.941200
DES	-0.21105	0.000000	0.730153
LEV	-0.9412	-0.73015	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34395

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-3.40308	-2.23756	-1.47192
DES	-2.23756	-0.64057	0.24248
LEV	-1.47192	0.24248	-0.25559

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	67	9.902573	5.255892	5.193390
DES	1891	6.982971	3.893166	3.845981
LEV	11878	8.598785	4.252223	4.200651

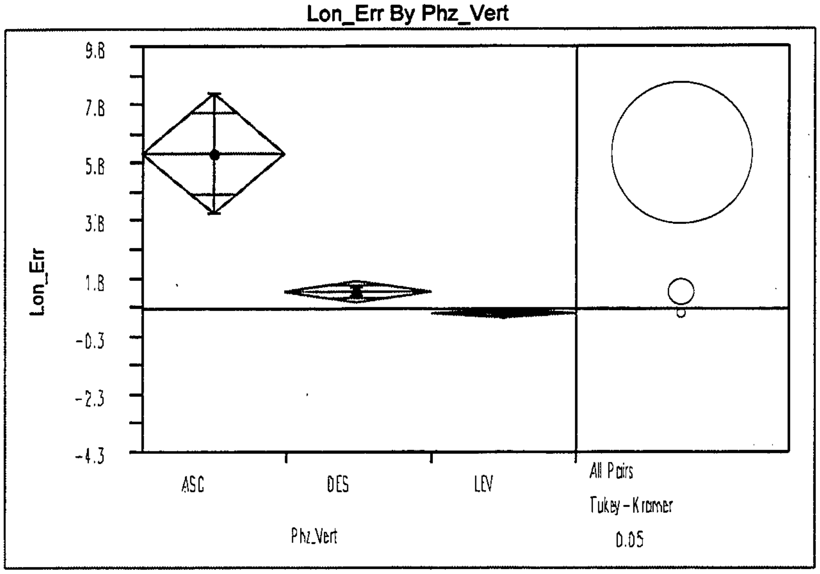
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.3091	2	13833	0.0366
Brown-Forsythe	2.5977	2	13833	0.0745
Levene	2.6874	2	13833	0.0681
Bartlett	65.6788	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.5118	2	173.21	0.0003

Figure A.1- 146 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	67	6.08724	17.3552	2.1203
DES	1891	1.32916	9.2307	0.2123
LEV	11878	0.56313	8.5338	0.0783

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	4.75808	5.52411
DES	-4.75808	0.00000	0.76602
LEV	-5.52411	-0.76602	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34395

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-3.52132	2.22441	3.02715
DES	2.22441	-0.66282	0.26141
LEV	3.02715	0.26141	-0.26447

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	67	17.35519	12.34545	12.34024
DES	1891	9.23068	6.38181	6.37956
LEV	11878	8.53376	5.53675	5.53671

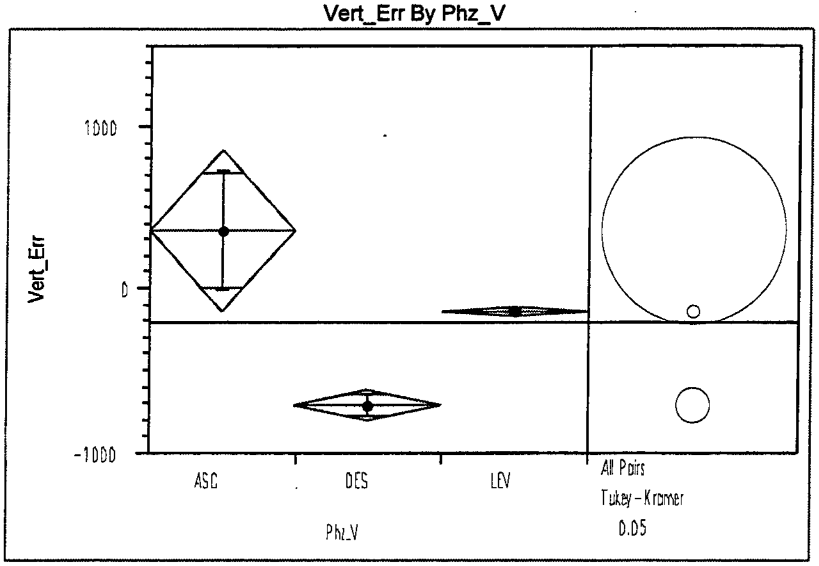
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	18.0889	2	13833	<.0001
Brown-Forsythe	48.1627	2	13833	<.0001
Levene	48.2980	2	13833	<.0001
Bartlett	63.8325	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.9750	2	171.75	0.0002

Figure A.1- 147 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Vert_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	67	366.593	3022.95	369.31
DES	1891	-692.948	3212.21	73.87
LEV	11878	-125.540	1861.58	17.08

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	492.13	1059.54
LEV	-492.13	0.00	567.41
DES	-1059.54	-567.41	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34395

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-852.259	-112.202	446.319
LEV	-112.202	-64.008	445.276
DES	446.319	445.276	-160.422

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	67	3022.946	1936.165	1904.832
DES	1891	3212.207	2391.171	2390.027
LEV	11878	1861.579	819.093	744.353

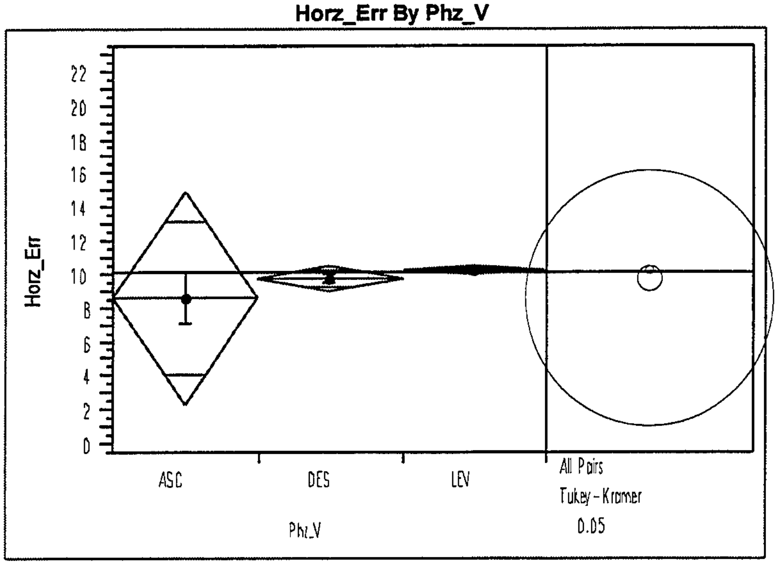
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	63.3912	2	13833	<.0001
Brown-Forsythe	705.9509	2	13833	<.0001
Levene	669.1486	2	13833	<.0001
Bartlett	631.8215	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
28.8846	2	171.3	<.0001

Figure A.1- 148 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	11	8.5964	5.0654	1.5273
DES	781	9.7114	9.3400	0.3342
LEV	5652	10.2329	11.1039	0.1477

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	DES	ASC
LEV	0.00000	0.52155	1.63647
DES	-0.52155	0.00000	1.11492
ASC	-1.63647	-1.11492	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34424

Abs(Dif)-LSD	LEV	DES	ASC
LEV	-0.4806	-0.4538	-6.0743
DES	-0.4538	-1.2929	-6.6424
ASC	-6.0743	-6.6424	-10.8941

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	11	5.06535	3.624998	3.007345
DES	781	9.34000	6.418944	5.989695
LEV	5652	11.10395	7.102620	6.565134

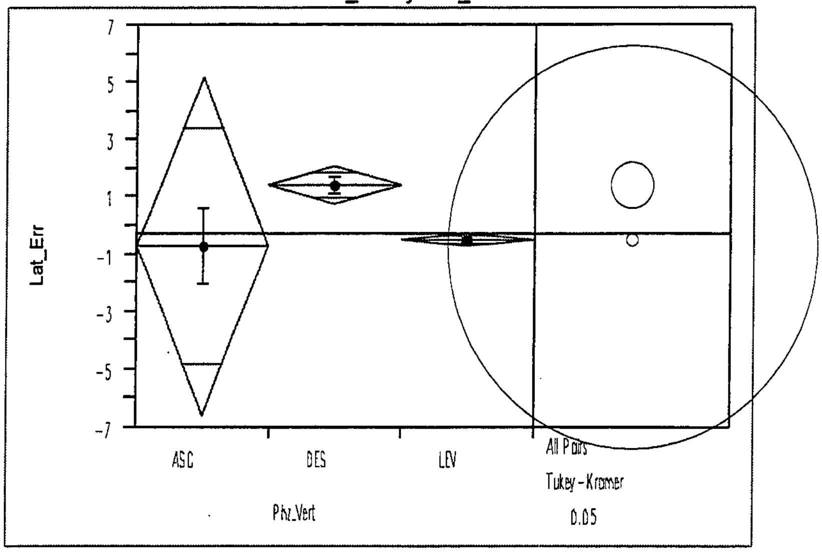
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.2850	2	6441	0.2767
Brown-Forsythe	2.0928	2	6441	0.1234
Levene	3.2181	2	6441	0.0401
Bartlett	22.1665	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.4934	2	26.839	0.2427

Figure A.1- 149 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	11	-0.66729	4.5378	1.3682
DES	781	1.43987	8.5302	0.3052
LEV	5652	-0.45051	10.2374	0.1362

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	LEV	ASC
DES	0.00000	1.89037	2.10716
LEV	-1.89037	0.00000	0.21678
ASC	-2.10716	-0.21678	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34424

Abs(Dif)-LSD	DES	LEV	ASC
DES	-1.1910	0.9919	-5.0388
LEV	0.9919	-0.4427	-6.8863
ASC	-5.0388	-6.8863	-10.0355

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	11	4.53782	2.342874	1.988864
DES	781	8.53021	4.643592	4.332618
LEV	5652	10.23743	4.896145	4.803751

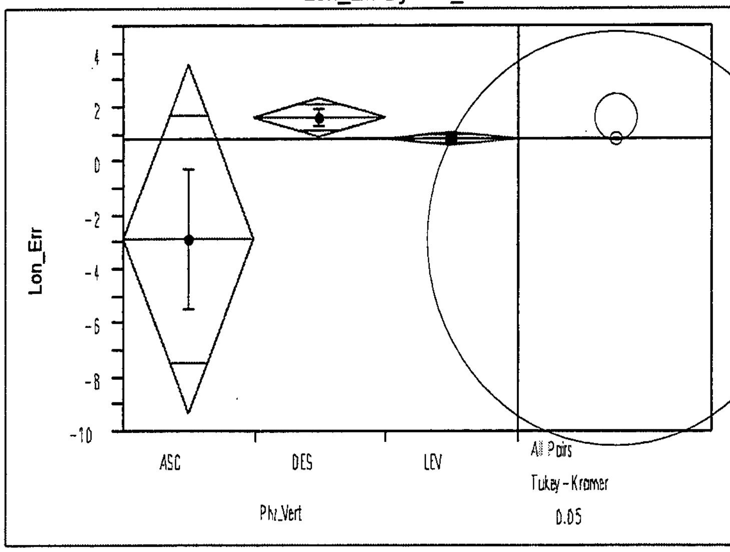
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.0921	2	6441	0.3356
Brown-Forsythe	1.4992	2	6441	0.2234
Levene	0.7367	2	6441	0.4787
Bartlett	24.3585	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
15.6798	2	26.863	<.0001

Figure A.1- 150 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	11	-2.91244	8.7484	2.6377
DES	781	1.57001	10.2156	0.3655
LEV	5652	0.78698	11.0635	0.1472

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	LEV	ASC
DES	0.00000	0.78303	4.48245
LEV	-0.78303	0.00000	3.69942
ASC	-4.48245	-3.69942	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34424

Abs(Dif)-LSD	DES	LEV	ASC
DES	-1.3003	-0.1979	-3.3194
LEV	-0.1979	-0.4834	-4.0556
ASC	-3.3194	-4.0556	-10.9566

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

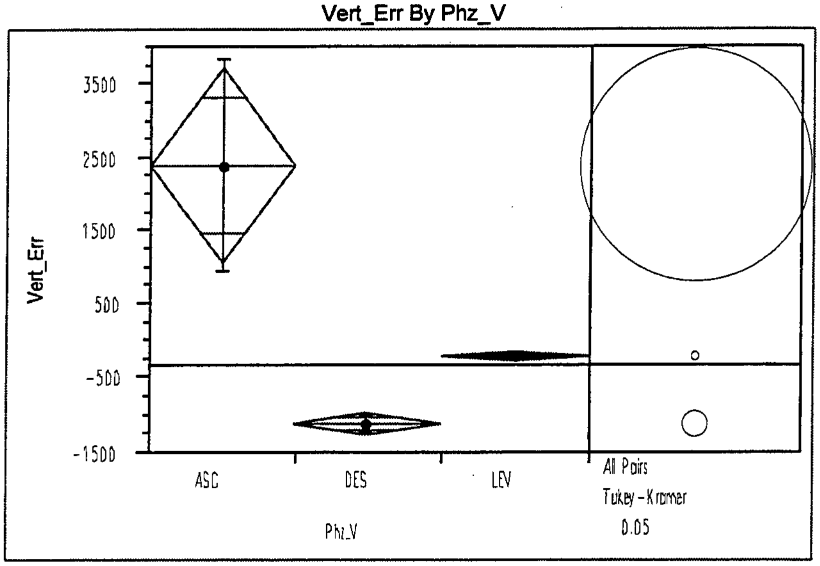
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	11	8.74840	6.867015	6.879182
DES	781	10.21560	7.191399	7.189635
LEV	5652	11.06351	7.398194	7.398110

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.8785	2	6441	0.4155
Brown-Forsythe	0.2470	2	6441	0.7811
Levene	0.2445	2	6441	0.7831
Bartlett	4.5491	2	?	0.0106

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.9401	2	26.555	0.0702

Figure A.1- 151 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	11	2367.53	4803.94	1448.4
DES	781	-1135.50	3374.12	120.7
LEV	5652	-220.69	2072.25	27.6

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	2588.22	3503.03
LEV	-2588.22	0.00	914.81
DES	-3503.03	-914.81	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34424

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2275.47	977.65	1882.74
LEV	977.65	-100.38	711.09
DES	1882.74	711.09	-270.05

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	11	4803.938	2701.043	2176.435
DES	781	3374.120	2569.823	2568.367
LEV	5652	2072.252	998.330	868.832

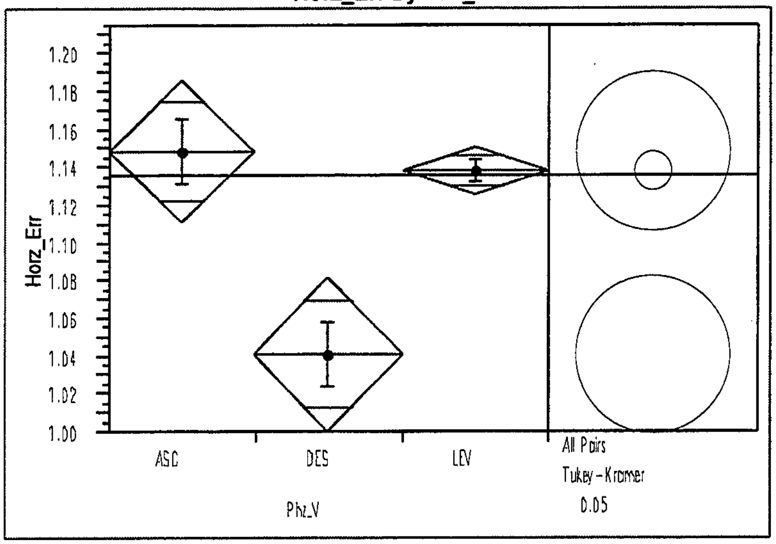
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	24.0650	2	6441	<.0001
Brown-Forsythe	265.3004	2	6441	<.0001
Levene	246.0753	2	6441	<.0001
Bartlett	212.9661	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
28.2223	2	26.379	<.0001

Figure A.1- 152 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2345	1.15130	0.870731	0.01798
DES	2012	1.04303	0.784722	0.01749
LEV	21791	1.14400	0.962867	0.00652

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000000	0.007301	0.108269
LEV	-0.0073	0.000000	0.100967
DES	-0.10827	-0.10097	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34383

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.0645	-0.0407	0.041149
LEV	-0.0407	-0.02116	0.049503
DES	0.041149	0.049503	-0.06964

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

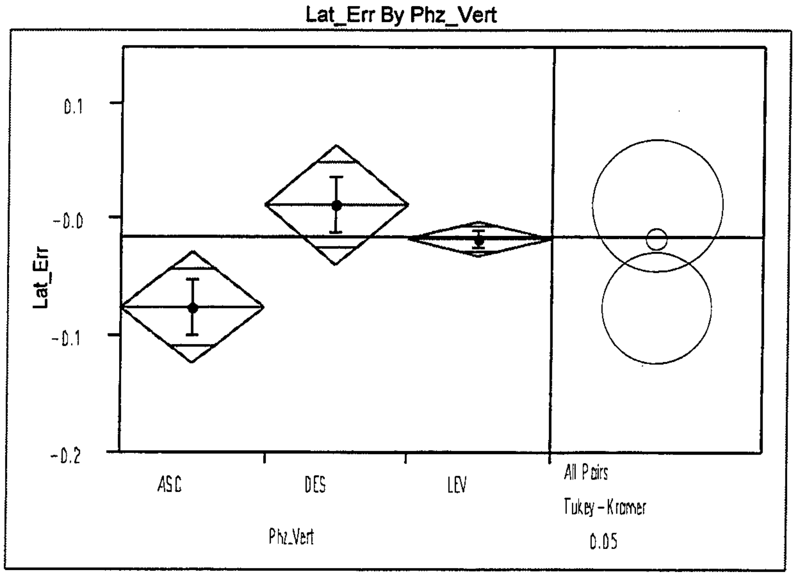
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2345	0.8707308	0.6552957	0.6368770
DES	2012	0.7847219	0.6138153	0.5928690
LEV	21791	0.9628669	0.6538652	0.6327879

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.7900	2	26145	0.4539
Brown-Forsythe	2.8765	2	26145	0.0563
Levene	3.2358	2	26145	0.0393
Bartlett	84.0044	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
15.1528	2	3606.9	<.0001

Figure A.1- 153 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2345	-0.07831	1.21484	0.02509
DES	2012	0.004360	1.11046	0.02476
LEV	21791	-0.02187	1.20537	0.00817

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	LEV	ASC
DES	0.000000	0.026231	0.082669
LEV	-0.02623	0.000000	0.056437
ASC	-0.08267	-0.05644	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34383

Abs(Dif)-LSD	DES	LEV	ASC
DES	-0.08862	-0.03926	-0.00274
LEV	-0.03926	-0.02693	-0.00465
ASC	-0.00274	-0.00465	-0.08208

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

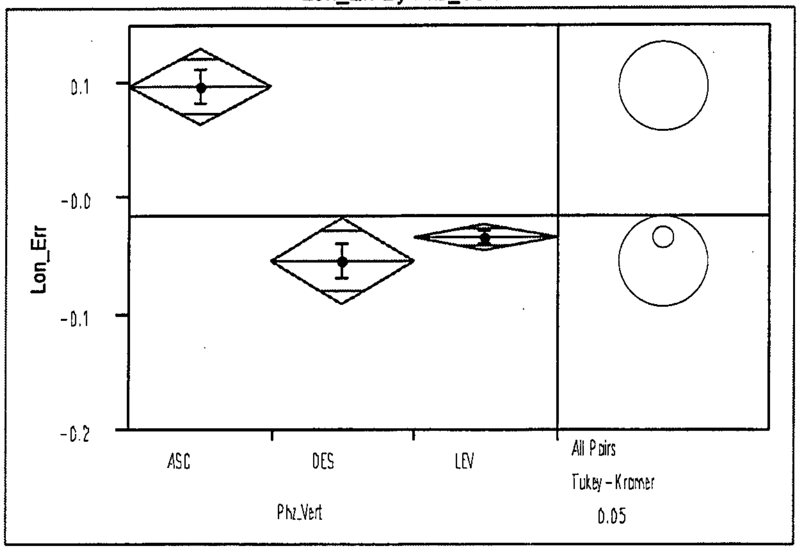
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2345	1.214843	0.8550664	0.8544570
DES	2012	1.110456	0.7525471	0.7524417
LEV	21791	1.205367	0.8030197	0.8025734

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.8467	2	26145	0.4288
Brown-Forsythe	7.1615	2	26145	0.0008
Levene	7.2410	2	26145	0.0007
Bartlett	12.2711	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.0310	2	3467.4	0.0484

Figure A.1- 154 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2345	0.090018	0.770811	0.01592
DES	2012	-0.05311	0.684320	0.01526
LEV	21791	-0.03422	0.883940	0.00599

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000000	0.124241	0.143130
LEV	-0.12424	0.000000	0.018889
DES	-0.14313	-0.01889	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34383

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.0589	0.080407	0.081839
LEV	0.080407	-0.01932	-0.02811
DES	0.081839	-0.02811	-0.06359

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2345	0.7708108	0.5525002	0.5517916
DES	2012	0.6843200	0.5256625	0.5251193
LEV	21791	0.8839398	0.6007800	0.6007332

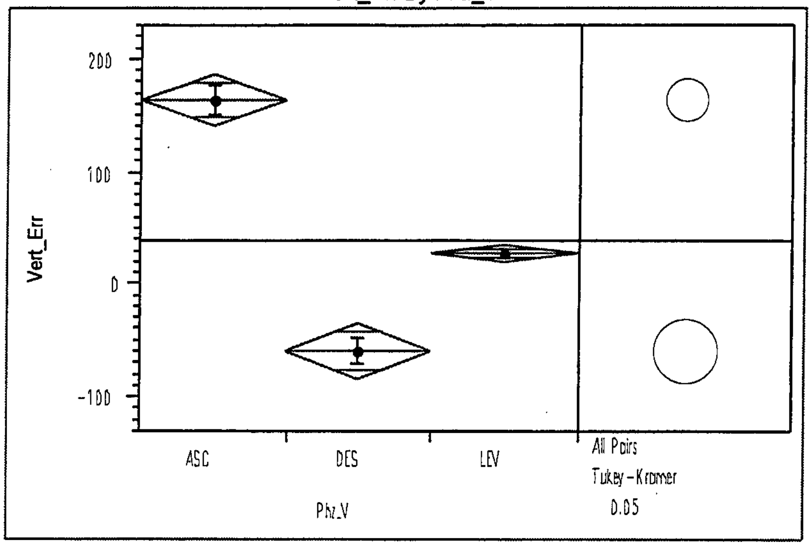
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.6021	2	26145	0.0741
Brown-Forsythe	18.3921	2	26145	<.0001
Levene	18.0895	2	26145	<.0001
Bartlett	133.5388	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
28.9052	2	3668.4	<.0001

Figure A.1- 155 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2345	164.895	689.815	14.245
DES	2012	-54.944	548.348	12.225
LEV	21791	33.862	582.105	3.943

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000	131.034	219.839
LEV	-131.034	0.000	88.805
DES	-219.839	-88.805	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34383

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-40.391	100.976	177.810
LEV	100.976	-13.250	56.580
DES	177.810	56.580	-43.605

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2345	689.8154	427.7717	425.2546
DES	2012	548.3482	409.4158	409.4063
LEV	21791	582.1048	104.2496	79.2132

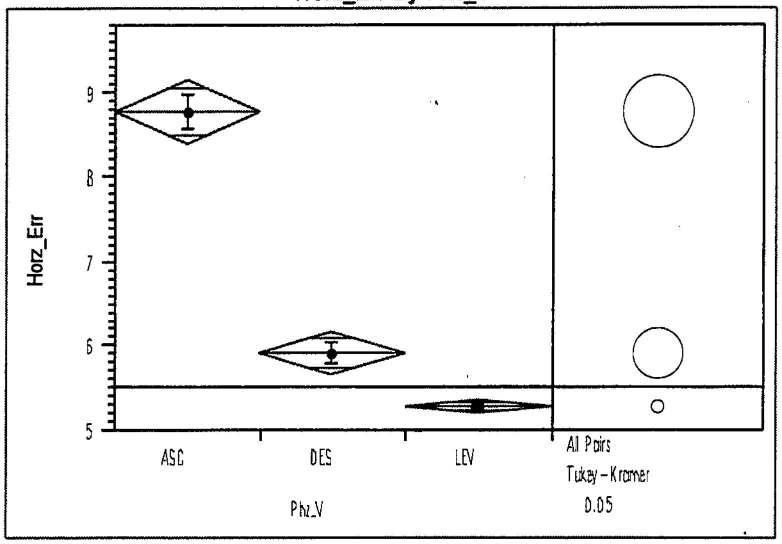
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.1437	2	26145	0.8661
Brown-Forsythe	661.5128	2	26145	<.0001
Levene	582.1952	2	26145	<.0001
Bartlett	77.9068	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
68.6614	2	3385.8	<.0001

Figure A.1- 156 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	790	8.50273	6.35945	0.22626
DES	1599	5.64080	5.70905	0.14277
LEV	15821	5.01378	5.61371	0.04463

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	2.86194	3.48895
DES	-2.86194	0.00000	0.62701
LEV	-3.48895	-0.62701	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34389

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.66709	2.28537	3.00561
DES	2.28537	-0.46889	0.27911
LEV	3.00561	0.27911	-0.14907

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

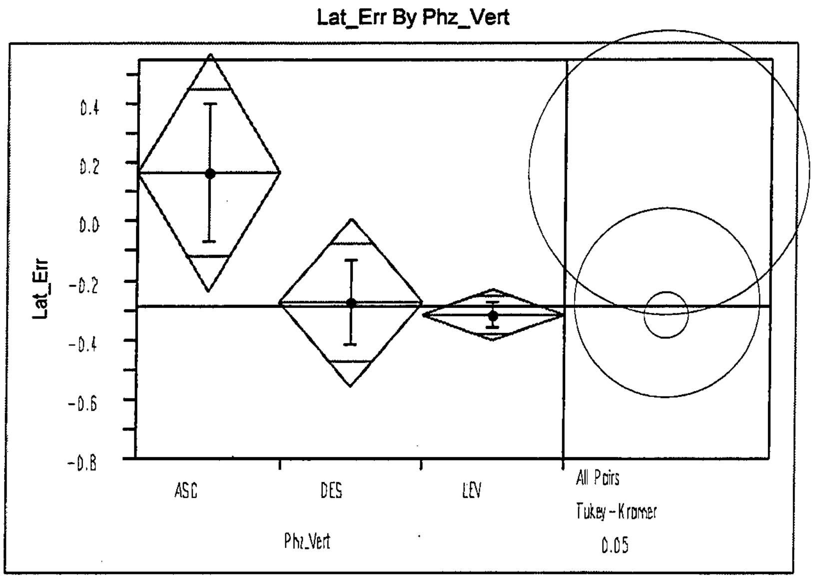
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	790	6.359453	5.014433	4.848607
DES	1599	5.709050	3.981934	3.676897
LEV	15821	5.613709	3.684837	3.350665

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.7348	2	18207	0.4796
Brown-Forsythe	38.5177	2	18207	<.0001
Levene	39.7989	2	18207	<.0001
Bartlett	12.7644	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
119.9102	2	1563.2	<.0001

Figure A.1- 157 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	790	0.229566	6.73511	0.23962
DES	1599	-0.18682	5.73576	0.14344
LEV	15821	-0.26056	5.77479	0.04591

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.000000	0.416381	0.490126
DES	-0.41638	0.000000	0.073745
LEV	-0.49013	-0.07375	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34389

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.68594	-0.17648	-0.00687
DES	-0.17648	-0.48214	-0.284
LEV	-0.00687	-0.284	-0.15328

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	790	6.735109	4.017441	4.005424
DES	1599	5.735762	3.189536	3.171637
LEV	15821	5.774790	3.036701	2.999845

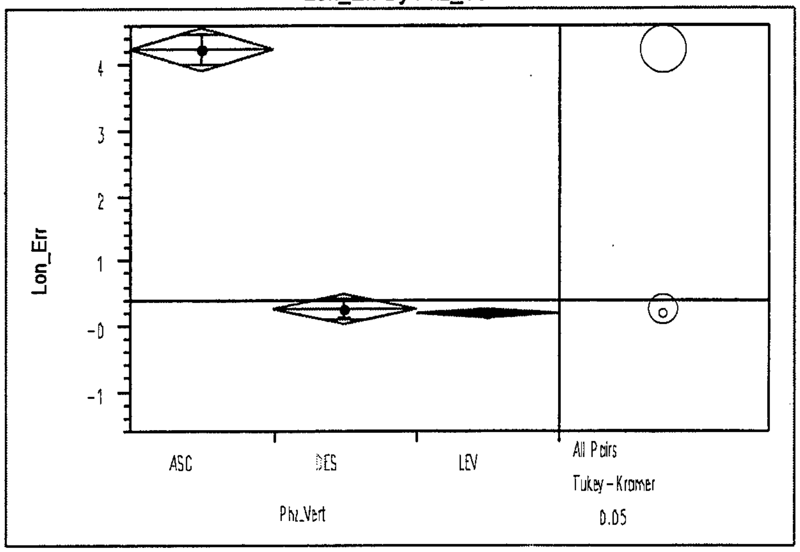
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.3574	2	18207	0.0947
Brown-Forsythe	15.9928	2	18207	<.0001
Levene	15.2786	2	18207	<.0001
Bartlett	19.8710	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.0872	2	1562.8	0.1244

Figure A.1- 158 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	790	4.26534	7.01428	0.24956
DES	1599	0.28032	5.60529	0.14018
LEV	15821	0.21882	4.81553	0.03828

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	3.98502	4.04652
DES	-3.98502	0.00000	0.06149
LEV	-4.04652	-0.06149	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34389

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.59013	3.47497	3.61894
DES	3.47497	-0.41480	-0.24628
LEV	3.61894	-0.24628	-0.13187

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

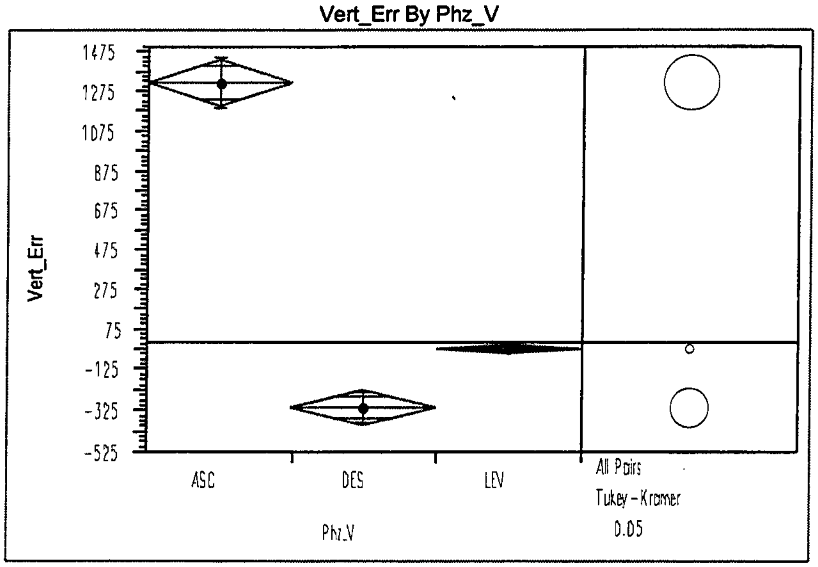
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	790	7.014278	5.380801	5.350096
DES	1599	5.605288	3.669638	3.663329
LEV	15821	4.815533	3.053748	3.052405

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	15.3261	2	18207	<.0001
Brown-Forsythe	149.0593	2	18207	<.0001
Levene	153.3746	2	18207	<.0001
Bartlett	159.0890	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
128.4044	2	1517	<.0001

Figure A.1- 159 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	790	1329.85	3826.34	136.14
DES	1599	-307.77	3063.43	76.61
LEV	15821	-20.23	1426.57	11.34

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	1350.08	1637.62
LEV	-1350.08	0.00	287.54
DES	-1637.62	-287.54	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34389

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-211.84	1196.59	1454.53
LEV	1196.59	-47.34	177.06
DES	1454.53	177.06	-148.90

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	790	3826.340	2892.154	2878.453
DES	1599	3063.425	2243.293	2223.390
LEV	15821	1426.566	520.903	507.304

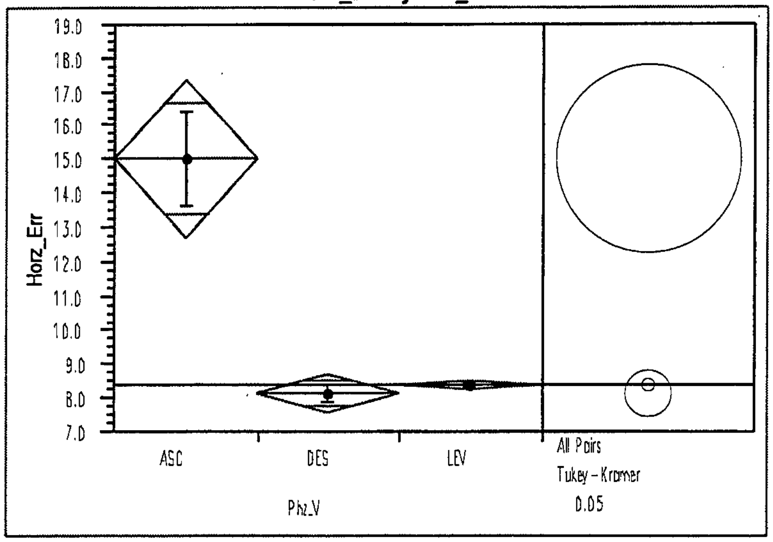
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	500.6528	2	18207	<.0001
Brown-Forsythe	1794.4347	2	18207	0.0000
Levene	1832.2859	2	18207	0.0000
Bartlett	2194.7295	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
56.1576	2	1441.6	<.0001

Figure A.1- 160 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	60	15.1133	11.1476	1.4391
DES	954	8.1625	8.1071	0.2625
LEV	9360	8.4334	9.4055	0.0972

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	6.67988	6.95079
LEV	-6.67988	0.00000	0.27090
DES	-6.95079	-0.27090	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34404

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-3.98207	3.85512	4.04784
LEV	3.85512	-0.31882	-0.47036
DES	4.04784	-0.47036	-0.99864

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

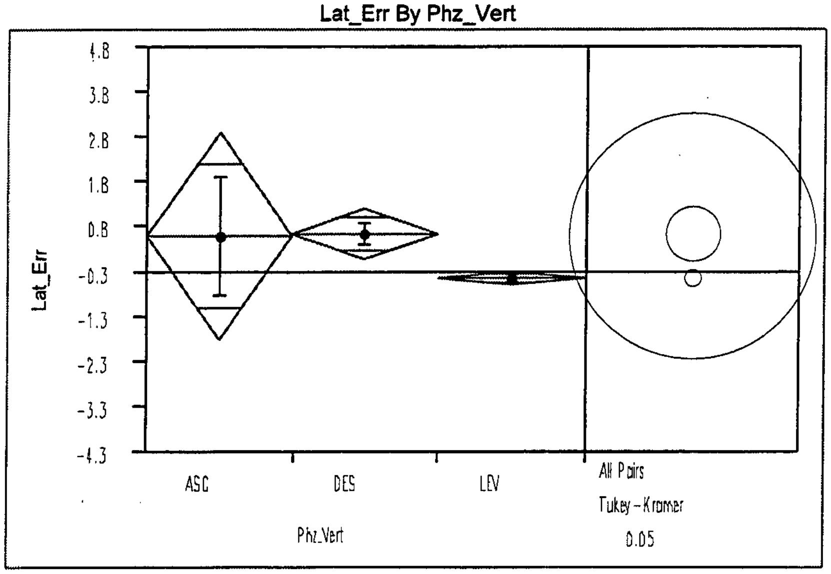
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	60	11.14761	8.926659	8.792062
DES	954	8.10711	5.683671	5.332744
LEV	9360	9.40554	6.027817	5.546812

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.8049	2	10371	0.4472
Brown-Forsythe	5.3426	2	10371	0.0048
Levene	6.1057	2	10371	0.0022
Bartlett	19.7546	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
11.2529	2	151.28	<.0001

Figure A.1- 161 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	60	0.544405	10.3652	1.3381
DES	954	0.639600	7.8553	0.2543
LEV	9360	-0.36263	9.2916	0.0960

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	ASC	LEV
DES	0.00000	0.09520	1.00223
ASC	-0.09520	0.00000	0.90704
LEV	-1.00223	-0.90704	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34404

Abs(Dif)-LSD	DES	ASC	LEV
DES	-0.98478	-2.76745	0.27126
ASC	-2.76745	-3.92679	-1.87851
LEV	0.27126	-1.87851	-0.31439

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

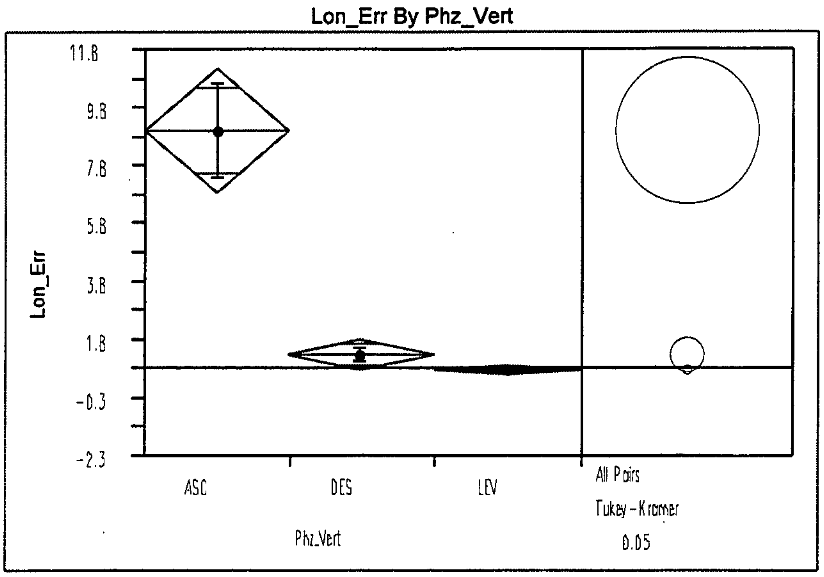
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	60	10.36523	5.448780	5.400325
DES	954	7.85527	4.379056	4.274972
LEV	9360	9.29163	4.686891	4.621213

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.3199	2	10371	0.2672
Brown-Forsythe	1.1313	2	10371	0.3226
Levene	0.9555	2	10371	0.3846
Bartlett	23.1685	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.9352	2	151.48	0.0013

Figure A.1- 162 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	60	8.98926	12.9088	1.6665
DES	954	1.25311	8.2907	0.2684
LEV	9360	0.69940	8.5229	0.0881

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	7.73615	8.28985
DES	-7.73615	0.00000	0.55371
LEV	-8.28985	-0.55371	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34404

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-3.65187	5.07392	5.69933
DES	5.07392	-0.91583	-0.12609
LEV	5.69933	-0.12609	-0.29238

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

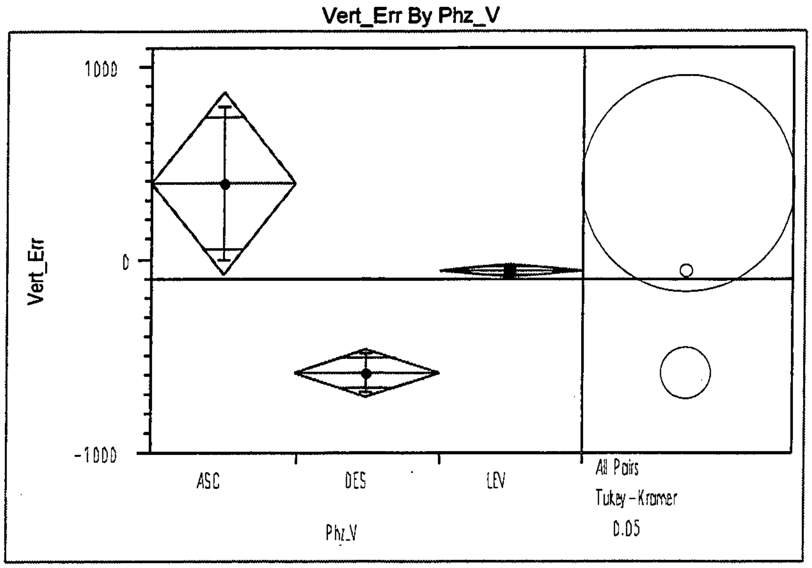
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	60	12.90878	10.76249	10.68907
DES	954	8.29067	5.49484	5.49171
LEV	9360	8.52287	5.51051	5.50763

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.3405	2	10371	0.0963
Brown-Forsythe	19.0557	2	10371	<.0001
Levene	19.6194	2	10371	<.0001
Bartlett	14.3354	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.0398	2	150.48	<.0001

Figure A.1- 163 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	60	393.245	3155.29	407.35
DES	954	-580.416	3150.19	101.99
LEV	9360	-57.599	1735.54	17.94

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000	450.844	973.661
LEV	-450.844	0.000	522.817
DES	-973.661	-522.817	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34404

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-821.719	-132.059	374.624
LEV	-132.059	-65.790	369.854
DES	374.624	369.854	-206.075

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	60	3155.288	2032.020	1986.479
DES	954	3150.193	2296.068	2290.300
LEV	9360	1735.538	640.975	603.384

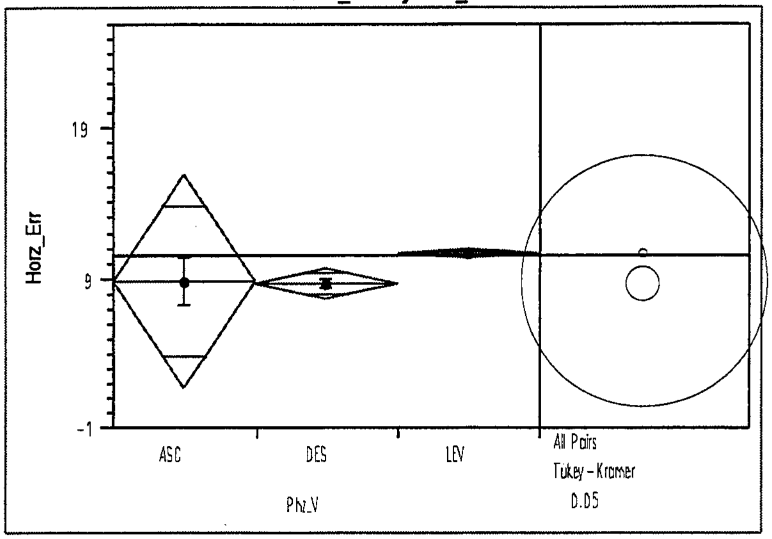
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	29.8949	2	10371	<.0001
Brown-Forsythe	446.4619	2	10371	<.0001
Levene	438.7175	2	10371	<.0001
Bartlett	443.2608	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
13.3392	2	149.2	<.0001

Figure A.1- 164 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_V



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	10	8.8798	5.2467	1.6591
DES	435	8.6888	8.4504	0.4052
LEV	4446	10.8108	11.8025	0.1770

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.00000	1.93105	2.12201
ASC	-1.93105	0.00000	0.19096
DES	-2.12201	-0.19096	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-0.5736	-6.6305	0.7634
ASC	-6.6305	-12.0943	-8.4588
DES	0.7634	-8.4588	-1.8337

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

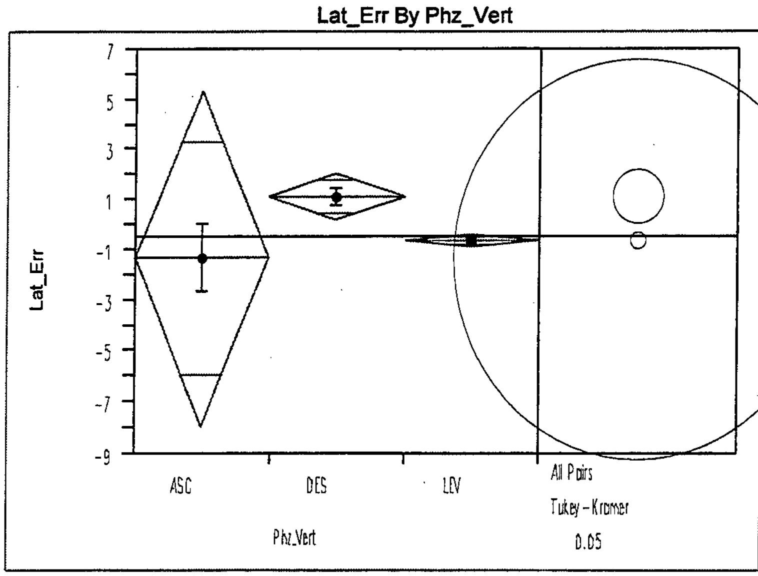
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	10	5.24666	3.817498	3.166610
DES	435	8.45044	5.712232	5.272187
LEV	4446	11.80248	7.524539	6.968179

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.0195	2	4888	0.1328
Brown-Forsythe	6.5529	2	4888	0.0014
Levene	9.0729	2	4888	0.0001
Bartlett	39.6519	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
11.6500	2	24.099	0.0003

Figure A.1- 165 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	10	-1.23892	4.3458	1.3743
DES	435	1.16046	7.5323	0.3611
LEV	4446	-0.59905	11.0126	0.1652

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	LEV	ASC
DES	0.00000	1.75951	2.39938
LEV	-1.75951	0.00000	0.63987
ASC	-2.39938	-0.63987	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	DES	LEV	ASC
DES	-1.7074	0.4945	-5.6543
LEV	0.4945	-0.5341	-7.3317
ASC	-5.6543	-7.3317	-11.2609

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

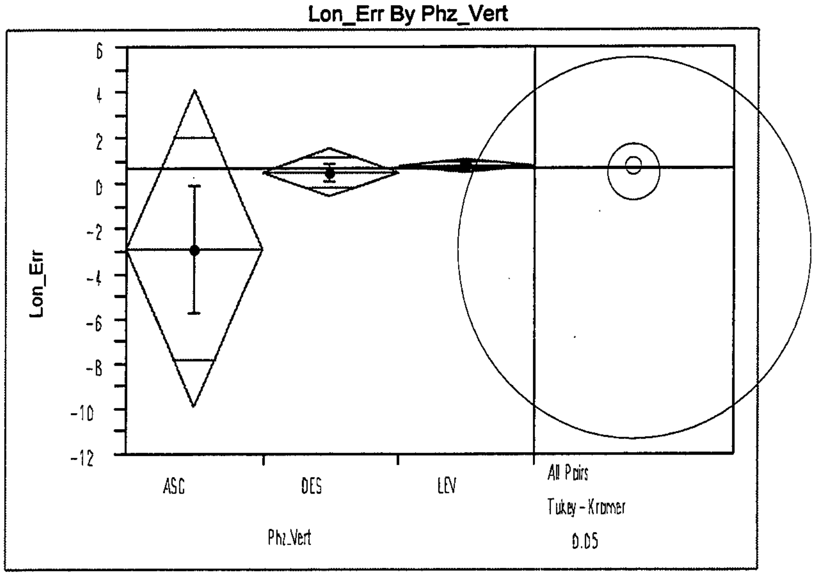
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	10	4.34581	2.462836	1.686380
DES	435	7.53227	4.073409	3.830838
LEV	4446	11.01258	5.357557	5.209377

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.9542	2	4888	0.1418
Brown-Forsythe	4.8354	2	4888	0.0080
Levene	4.1621	2	4888	0.0156
Bartlett	49.9821	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
9.7795	2	24.222	0.0008

Figure A.1- 166 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	10	-2.92582	9.2215	2.9161
DES	435	0.54567	9.4178	0.4516
LEV	4446	0.80756	11.5720	0.1735

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	DES	ASC
LEV	0.00000	0.26189	3.73338
DES	-0.26189	0.00000	3.47149
ASC	-3.73338	-3.47149	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	LEV	DES	ASC
LEV	-0.5665	-1.0800	-4.7227
DES	-1.0800	-1.8111	-5.0717
ASC	-4.7227	-5.0717	-11.9453

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

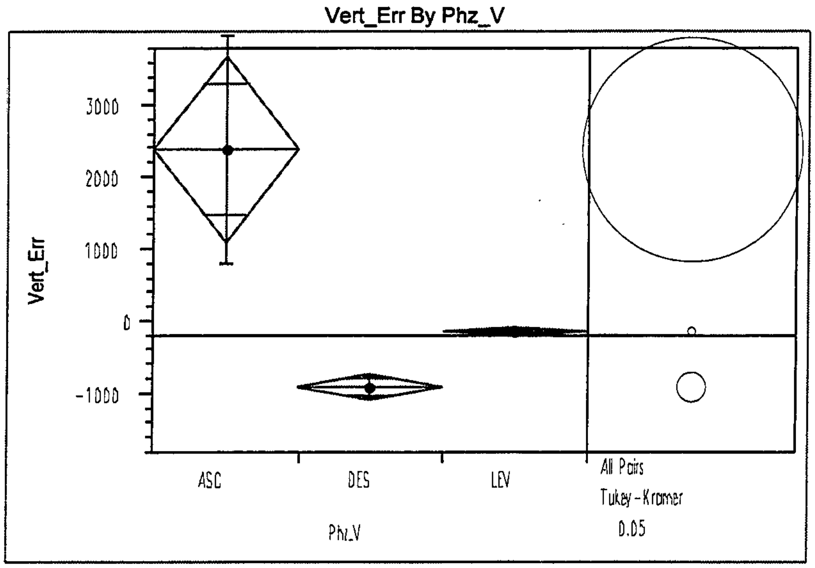
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	10	9.22151	7.537656	7.346080
DES	435	9.41785	6.429918	6.428583
LEV	4446	11.57197	7.704713	7.703998

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.4490	2	4888	0.0865
Brown-Forsythe	4.4769	2	4888	0.0114
Levene	4.4709	2	4888	0.0115
Bartlett	15.0694	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.9230	2	23.771	0.4111

Figure A.1- 167 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	10	2414.28	5061.16	1600.5
DES	435	-891.51	3299.07	158.2
LEV	4446	-116.41	1966.69	29.5

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	2530.69	3305.79
LEV	-2530.69	0.00	775.10
DES	-3305.79	-775.10	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34442

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2231.72	950.85	1709.69
LEV	950.85	-105.84	524.40
DES	1709.69	524.40	-338.37

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	10	5061.157	2952.446	2267.479
DES	435	3299.071	2467.997	2467.877
LEV	4446	1966.689	795.071	721.228

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	12.7046	2	4888	<.0001
Brown-Forsythe	174.2590	2	4888	<.0001
Levene	169.1966	2	4888	<.0001
Bartlett	150.7959	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
12.5235	2	23.559	0.0002

Figure A.1- 168 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

A.2 CTAS

A.2.1 Look Ahead Time

A.2.1.1 Summary Tables

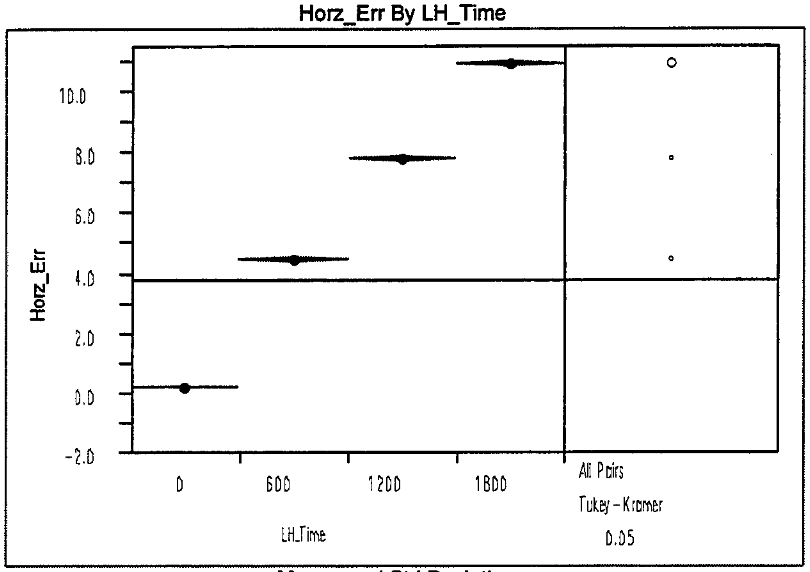
Look Ahead Time (sec)	0	300	600	900	1200	1500	1800
Sample Quantity	32609	27163	21908	16941	12921	9261	6657
Avg. Horz. Error	0.28	2.64	4.53	6.21	7.82	9.4	10.94
Stddev. Horz. Error	0.85	3.19	4.95	6.56	8.12	9.76	11.22
Max. Horz. Error	48.02	88.45	67.08	101.09	103.04	94.14	98.82
Min. Horz. Error	0	0	0.01	0.01	0.01	0.03	0.03
Avg. Lat. Error	0	0.03	0.24	0.46	0.56	0.46	0.46
Stddev. Lat. Error	0.45	3.3	5.03	6.33	7.46	8.55	9.39
Max. Lat. Error	22.88	46.61	55.5	60.84	76.1	85.67	86.54
Min. Lat. Error	-15.57	-46.12	-38.27	-64.27	-55.56	-65.63	-62.21
Avg. Abs. Lat. Error	0.13	1.73	2.66	3.33	3.92	4.42	4.87
Stddev. Abs. Lat. Error	0.44	2.81	4.28	5.41	6.37	7.34	8.05
Max. Abs. Lat. Error	22.88	46.61	55.5	64.27	76.1	85.67	86.54
Min. Abs. Lat. Error	0	0	0	0	0	0	0
Avg. Long. Error	-0.05	-0.06	0.29	0.64	1.19	1.86	2.43
Stddev. Long. Error	0.77	2.5	4.43	6.39	8.35	10.34	12.3
Max. Long. Error	47.54	46.01	59.63	58.31	77.59	94.14	96.86
Min. Long. Error	-31.16	-87.99	-59.56	-83.04	-94.35	-73.71	-78.6
Avg. Abs. Long. Error	0.21	1.48	2.83	4.14	5.46	6.79	8.13
Stddev. Abs. Long. Error	0.74	2.01	3.42	4.92	6.43	8.01	9.54
Max. Abs. Long. Error	47.54	87.99	59.63	83.04	94.35	94.14	96.86
Min. Abs. Long. Error	0	0	0	0	0	0	0
Avg. Vert. Error	-98.82	-527.89	-759.82	-912.93	-1053.07	-1151.01	-1266.59
Stddev. Vert. Error	789.35	2159.92	2844.69	3359.14	3580.43	3697.21	3868.81
Max. Vert. Error	18889	27290	28990	29003	29003	29003	29003
Min. Vert. Error	-31466.5	-24677	-26868	-32426	-28868	-27901	-29635
Avg. Abs. Vert. Error	154	1061.62	1503.76	1785.4	1940.87	2028.25	2163.38
Stddev. Abs. Vert. Error	780.46	1953.68	2531.44	2988.23	3187.68	3298.5	3448.37
Max. Abs. Vert. Error	31466.46	27290	28990	32426	29003	29003	29635
Min. Abs. Vert. Error	0	0	0	0	0	0	0
Avg. Slant Range Error	0.28	2.67	4.56	6.25	7.86	9.44	10.98
Stddev. Slant Range Error	0.86	3.19	4.95	6.55	8.1	9.74	11.2
Max. Slant Range Error	48.03	88.56	67.09	101.09	103.05	94.14	98.82
Min. Slant Range Error	0	0.01	0.01	0.01	0.01	0.03	0.03

Figure A.2- 1 Descriptive Statistics for Look Ahead Times 0 to 1800 Seconds from All Samples

Look Ahead Time (sec)	0	300	600	900	1200	1500	1800
Sample Quantity	21209	18451	14807	11217	8189	5705	3917
Avg. Horz. Error	0.25	2.5	4.41	6.13	7.79	9.13	10.34
Stddev. Horz. Error	0.75	3.31	5.16	6.77	8.43	9.83	11.08
Max. Horz. Error	48.02	88.45	67.08	75.25	86.73	87.22	87.65
Min. Horz. Error	0	0	0.01	0.01	0.01	0.03	0.03
Avg. Lat. Error	0	0.06	0.33	0.66	0.86	0.76	0.71
Stddev. Lat. Error	0.41	3.46	5.36	6.9	8.25	9.49	10.33
Max. Lat. Error	22.88	46.61	55.5	60.84	76.1	85.67	86.54
Min. Lat. Error	-15.57	-46.12	-38.27	-43.96	-55.56	-65.63	-62.21
Avg. Abs. Lat. Error	0.11	1.71	2.72	3.54	4.27	4.82	5.24
Stddev. Abs. Lat. Error	0.4	3.01	4.63	5.96	7.11	8.21	8.93
Max. Abs. Lat. Error	22.88	46.61	55.5	60.84	76.1	85.67	86.54
Min. Abs. Lat. Error	0	0	0	0	0	0	0
Avg. Long. Error	-0.04	0.04	0.31	0.43	0.7	0.8	0.84
Stddev. Long. Error	0.68	2.3	4.13	5.92	7.9	9.42	11.05
Max. Long. Error	47.54	46.01	59.63	58.31	77.59	63.91	77.47
Min. Long. Error	-31.16	-87.99	-29.72	-61.99	-85.87	-61.99	-58.65
Avg. Abs. Long. Error	0.19	1.32	2.6	3.8	5.06	6.09	7.06
Stddev. Abs. Long. Error	0.65	1.88	3.23	4.56	6.11	7.23	8.54
Max. Abs. Long. Error	47.54	87.99	59.63	61.99	85.87	63.91	77.47
Min. Abs. Long. Error	0	0	0	0	0	0	0
Avg. Vert. Error	-17.45	-143.41	-284.9	-267.38	-201.11	-180.72	-128.9
Stddev. Vert. Error	499.6	1778.12	2594.45	3017.1	3061.06	2990.64	3058.47
Max. Vert. Error	18889	27290	28990	29003	29003	29003	29003
Min. Vert. Error	-21500	-18228	-16708	-20550	-19633	-20550	-17851
Avg. Abs. Vert. Error	72.4	734.83	1177.4	1348.57	1343.89	1321.91	1359.03
Stddev. Abs. Vert. Error	494.63	1625.5	2329.37	2712.11	2757.59	2688.66	2742.89
Max. Abs. Vert. Error	21500	27290	28990	29003	29003	29003	29003
Min. Abs. Vert. Error	0	0	0	0	0	0	0
Avg. Slant Range Error	0.25	2.52	4.44	6.16	7.82	9.16	10.36
Stddev. Slant Range Error	0.76	3.31	5.15	6.76	8.42	9.82	11.08
Max. Slant Range Error	48.03	88.56	67.09	75.4	86.86	87.23	87.65
Min. Slant Range Error	0	0.01	0.01	0.01	0.01	0.03	0.03

Figure A.2- 2 Descriptive Statistics for Look Ahead Times 0 to 1800 Seconds from Samples at Altitudes Above 18,000 Feet

A.2.1.2 Statistical Tests



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	32609	0.2754	0.8489	0.00470
600	21908	4.5288	4.9547	0.03347
1200	12921	7.8219	8.1156	0.07140
1800	6657	10.9415	11.2172	0.13748

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.0000	3.1195	6.4127	10.6661
1200	-3.1195	0.0000	3.2932	7.5466
600	-6.4127	-3.2932	0.0000	4.2534
0	-10.6661	-7.5466	-4.2534	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.2454	2.9059	6.2146	10.4757
1200	2.9059	-0.1761	3.1361	7.3994
600	6.2146	3.1361	-0.1353	4.1298
0	10.4757	7.3994	4.1298	-0.1109

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

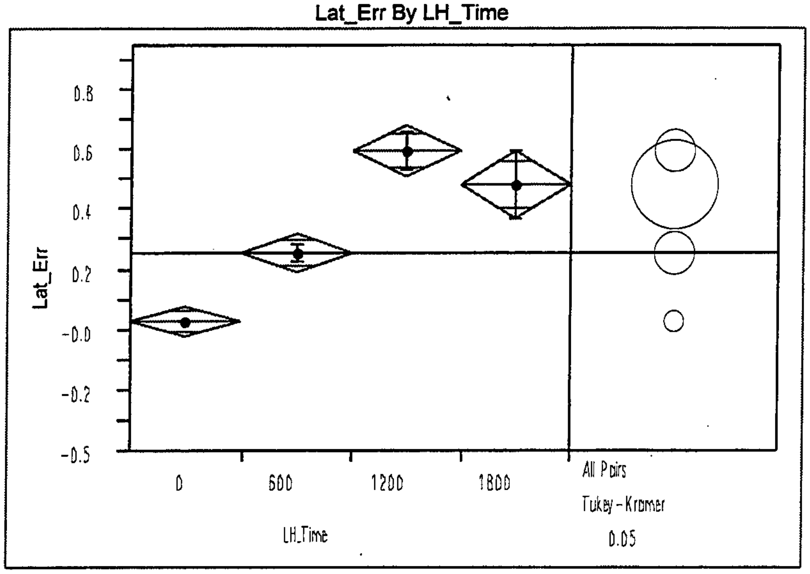
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	32609	0.84893	0.248551	0.204254
600	21908	4.95467	3.452990	3.165135
1200	12921	8.11562	5.811963	5.382548
1800	6657	11.21723	8.211165	7.559329

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1441.7847	3	74091	0.0000
Brown-Forsythe	7351.5399	3	74091	0.0000
Levene	11959.587	3	74091	0.0000
Bartlett	35722.914	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
10866.429	3	18479	0.0000

Figure A.2- 3 Statistical Tests for Horizontal Error and Look Ahead Time for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	32609	0.000470	0.45435	0.00252
600	21908	0.236306	5.03038	0.03399
1200	12921	0.562154	7.45748	0.06561
1800	6657	0.456111	9.39249	0.11512

Means Comparisons

Dif=Mean[i]-Mean[j]	1200	1800	600	0
1200	0.000000	0.106042	0.325848	0.561684
1800	-0.10604	0.000000	0.219806	0.455641
600	-0.32585	-0.21981	0.000000	0.235835
0	-0.56168	-0.45564	-0.23584	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	1200	1800	600	0
1200	-0.16044	-0.08851	0.182805	0.427630
1800	-0.08851	-0.22352	0.039329	0.282203
600	0.182805	0.039329	-0.12321	0.123183
0	0.427630	0.282203	0.123183	-0.10099

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	32609	0.454348	0.126259	0.126242
600	21908	5.030381	2.691498	2.655372
1200	12921	7.457478	4.036750	3.915983
1800	6657	9.392486	4.945310	4.868303

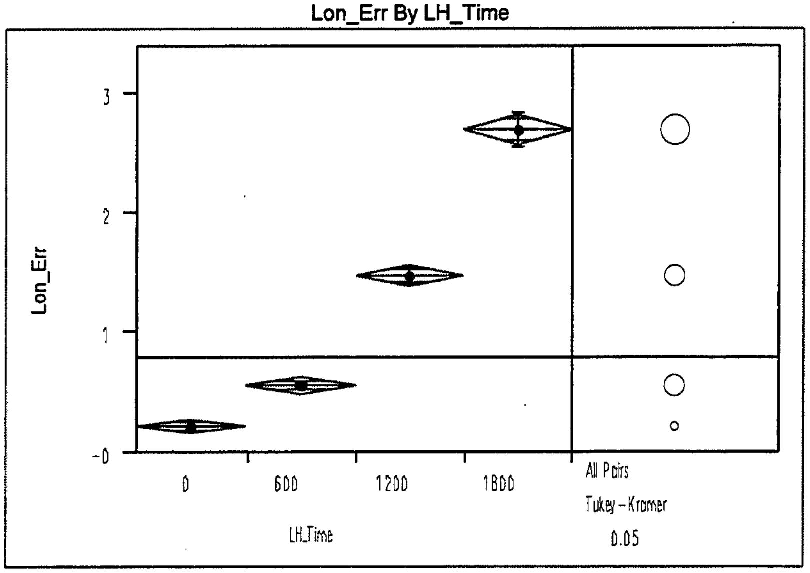
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	905.7122	3	74091	0.0000
Brown-Forsythe	4096.1593	3	74091	0.0000
Levene	4374.2475	3	74091	0.0000
Bartlett	45998.4	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
45.4172	3	18354	<.0001

Figure A.2- 4 Statistical Tests for Lateral Error and Look Ahead Time for Samples at All Altitudes

Lon_Err By LH_Time



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	32609	-0.04957	0.7666	0.00425
600	21908	0.29322	4.4286	0.02992
1200	12921	1.19392	8.3484	0.07344
1800	6657	2.42624	12.2982	0.15073

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.00000	1.23232	2.13302	2.47581
1200	-1.23232	0.00000	0.90070	1.24349
600	-2.13302	-0.90070	0.00000	0.34279
0	-2.47581	-1.24349	-0.34279	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.25111	1.01375	1.93027	2.28096
1200	1.01375	-0.18024	0.74001	1.09289
600	1.93027	0.74001	-0.13842	0.21623
0	2.28096	1.09289	0.21623	-0.11346

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	32609	0.76656	0.204627	0.204534
600	21908	4.42865	2.824441	2.822935
1200	12921	8.34837	5.438772	5.416451
1800	6657	12.29819	8.178568	8.062229

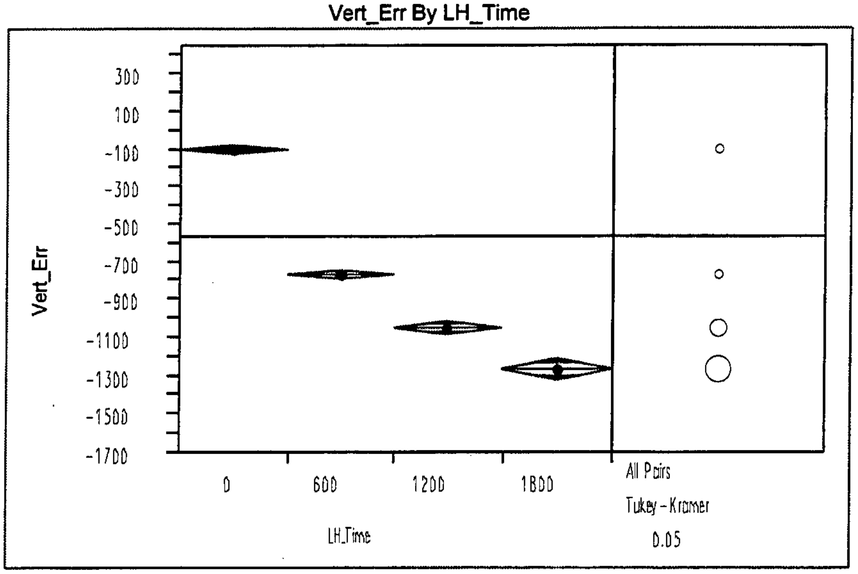
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1945.4371	3	74091	0.0000
Brown-Forsythe	8726.3921	3	74091	0.0000
Levene	9121.9444	3	74091	0.0000
Bartlett	40068.356	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
226.1604	3	18464	<.0001

Figure A.2- 5 Statistical Tests for Longitudinal Error and Look Ahead Time for Samples at All Altitudes

Vert_Err By LH_Time



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	32609	-98.82	789.35	4.371
600	21908	-759.82	2844.69	19.219
1200	12921	-1053.07	3580.43	31.498
1800	6657	-1266.59	3868.81	47.417

Means Comparisons

Dif=Mean[i]-Mean[j]	0	600	1200	1800
0	0.00	661.00	954.25	1167.76
600	-661.00	0.00	293.25	506.76
1200	-954.25	-293.25	0.00	213.51
1800	-1167.76	-506.76	-213.51	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56909

Abs(Dif)-LSD	0	600	1200	1800
0	-50.29	604.91	887.50	1081.40
600	604.91	-61.35	222.03	416.90
1200	887.50	222.03	-79.89	116.64
1800	1081.40	416.90	116.64	-111.30

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	32609	789.350	204.724	154.004
600	21908	2844.690	1804.238	1503.764
1200	12921	3580.432	2324.048	1940.867
1800	6657	3868.811	2619.756	2163.376

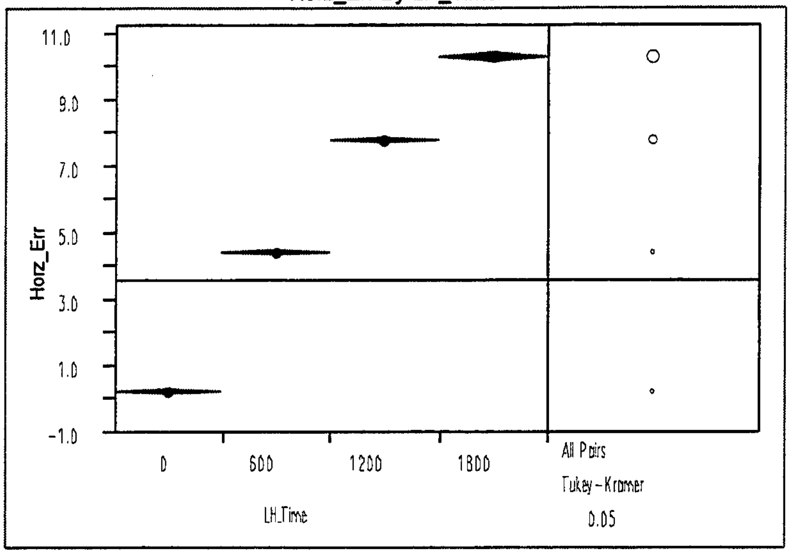
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	928.7413	3	74091	0.0000
Brown-Forsythe	3277.6670	3	74091	0.0000
Levene	6270.1902	3	74091	0.0000
Bartlett	18130.9	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
839.2193	3	18933	0.0000

Figure A.2- 6 Statistical Tests for Vertical Error and Look Ahead Time for Samples at All Altitudes

Horz_Err By LH_Time



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	21209	0.2490	0.7535	0.00517
600	14807	4.4124	5.1550	0.04236
1200	8189	7.7915	8.4267	0.09312
1800	3917	10.3445	11.0827	0.17708

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.0000	2.5529	5.9321	10.0955
1200	-2.5529	0.0000	3.3792	7.5426
600	-5.9321	-3.3792	0.0000	4.1634
0	-10.0955	-7.5426	-4.1634	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56912

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.32064	2.27728	5.67716	9.84875
1200	2.27728	-0.22176	3.18375	7.35797
600	5.67716	3.18375	-0.16492	4.01146
0	9.84875	7.35797	4.01146	-0.13780

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

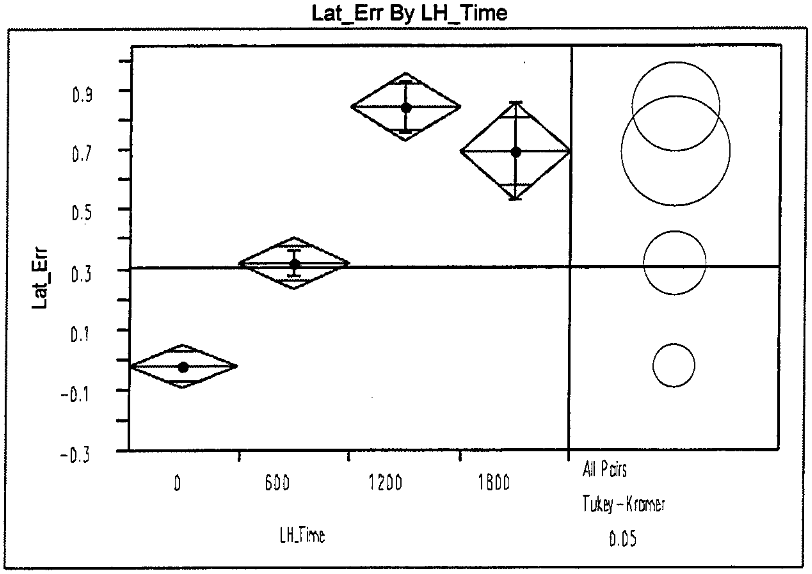
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	21209	0.75354	0.210933	0.176164
600	14807	5.15501	3.514434	3.163892
1200	8189	8.42674	5.973631	5.476191
1800	3917	11.08267	7.862517	7.195796

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	900.7762	3	48118	0.0000
Brown-Forsythe	4300.1517	3	48118	0.0000
Levene	7114.4988	3	48118	0.0000
Bartlett	24719.234	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6381.0736	3	11314	0.0000

Figure A.2- 7 Statistical Tests for Horizontal Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	21209	-0.00108	0.4117	0.00283
600	14807	0.328630	5.3616	0.04406
1200	8189	0.863553	8.2486	0.09115
1800	3917	0.709525	10.3269	0.16500

Means Comparisons

Dif=Mean[i]-Mean[j]	1200	1800	600	0
1200	0.000000	0.154027	0.534923	0.864633
1800	-0.15403	0.000000	0.380895	0.710606
600	-0.53492	-0.3809	0.000000	0.329711
0	-0.86463	-0.71061	-0.32971	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56912

Abs(Dif)-LSD	1200	1800	600	0
1200	-0.21687	-0.11557	0.343812	0.684086
1800	-0.11557	-0.31358	0.131553	0.469264
600	0.343812	0.131553	-0.16128	0.181096
0	0.684086	0.469264	0.181096	-0.13476

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

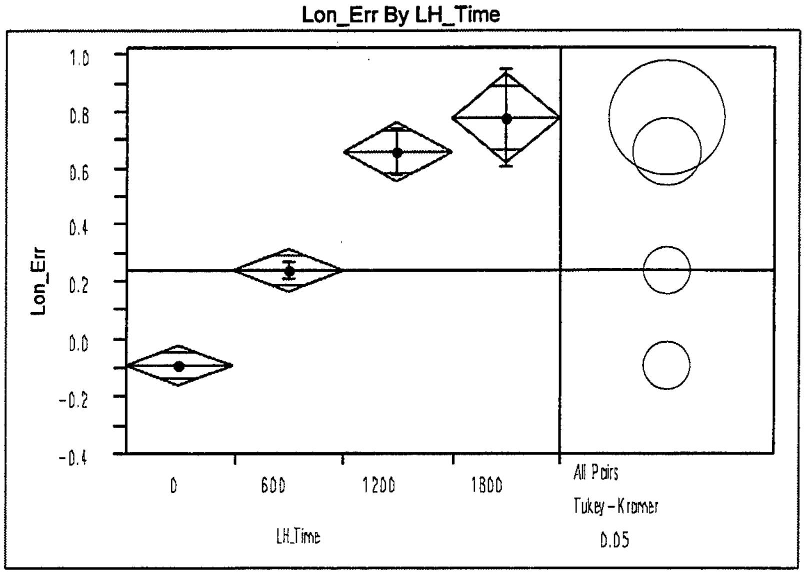
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	21209	0.41171	0.109176	0.109164
600	14807	5.36156	2.795106	2.723243
1200	8189	8.24865	4.504469	4.269265
1800	3917	10.32692	5.417549	5.240543

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	625.0230	3	48118	0.0000
Brown-Forsythe	2556.2337	3	48118	0.0000
Levene	2893.7115	3	48118	0.0000
Bartlett	32463.712	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
54.5945	3	11259	<.0001

Figure A.2- 8 Statistical Tests for Lateral Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	21209	-0.04456	0.6770	0.00465
600	14807	0.312483	4.1343	0.03398
1200	8189	0.702831	7.9022	0.08732
1800	3917	0.835682	11.0460	0.17649

Means Comparisons

Dif=Mean[i]-Mean[j]	1800	1200	600	0
1800	0.000000	0.132851	0.523199	0.880243
1200	-0.13285	0.000000	0.390348	0.747392
600	-0.5232	-0.39035	0.000000	0.357044
0	-0.88024	-0.74739	-0.35704	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56912

Abs(Dif)-LSD	1800	1200	600	0
1800	-0.29611	-0.12173	0.287746	0.652345
1200	-0.12173	-0.20479	0.209883	0.576902
600	0.287746	0.209883	-0.1523	0.216708
0	0.652345	0.576902	0.216708	-0.12725

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

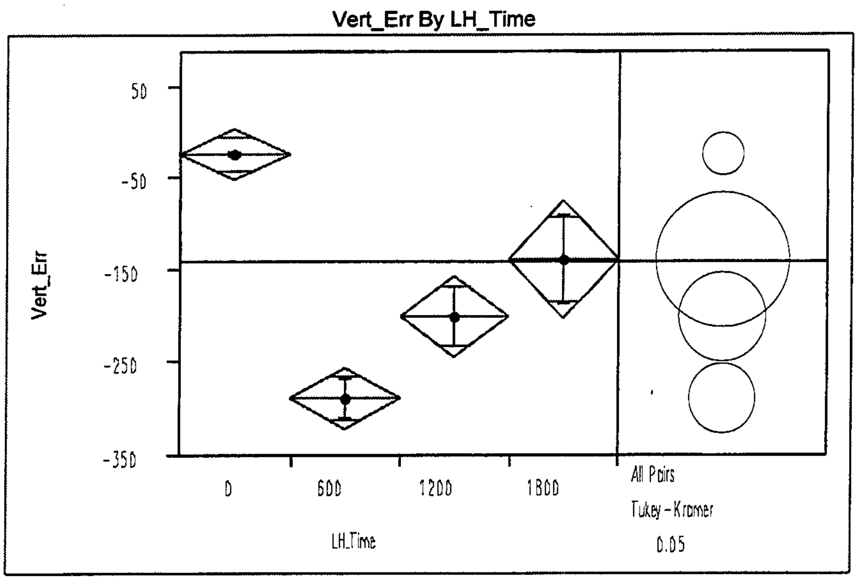
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	21209	0.67698	0.187322	0.187311
600	14807	4.13431	2.597534	2.592815
1200	8189	7.90224	5.063641	5.050070
1800	3917	11.04599	7.078687	7.051549

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1085.1001	3	48118	0.0000
Brown-Forsythe	5259.6511	3	48118	0.0000
Levene	5338.1311	3	48118	0.0000
Bartlett	26218.094	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
68.1760	3	11323	<.0001

Figure A.2- 9 Statistical Tests for Longitudinal Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
0	21209	-17.448	499.60	3.431
600	14807	-284.905	2594.45	21.321
1200	8189	-201.113	3061.06	33.826
1800	3917	-128.899	3058.47	48.868

Means Comparisons

Dif=Mean[i]-Mean[j]	0	1800	1200	600
0	0.000	111.450	183.664	267.456
1800	-111.450	0.000	72.214	156.006
1200	-183.664	-72.214	0.000	83.792
600	-267.456	-156.006	-83.792	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.56912

Abs(Dif)-LSD	0	1800	1200	600
0	-53.140	16.282	112.469	208.853
1800	16.282	-123.653	-34.096	57.683
1200	112.469	-34.096	-85.520	8.431
600	208.853	57.683	8.431	-63.599

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
0	21209	499.596	83.588	72.401
600	14807	2594.446	1335.927	1177.396
1200	8189	3061.063	1461.372	1343.885
1800	3917	3058.472	1438.069	1359.031

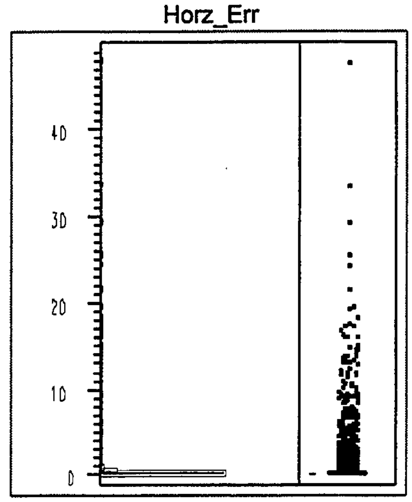
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	409.7103	3	48118	<.0001
Brown-Forsythe	1517.5682	3	48118	0.0000
Levene	1960.3021	3	48118	0.0000
Bartlett	15630.425	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
61.6208	3	11442	<.0001

Figure A.2- 10 Statistical Tests for Vertical Error and Look Ahead Time for Samples at Altitudes Above 18,000 Feet

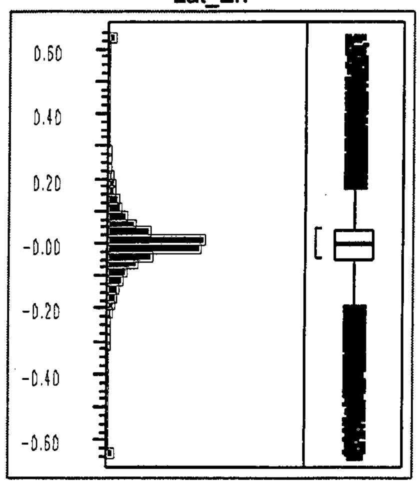
A.2.1.3 Histograms



	Quantiles	
maximum	100.0%	48.025
	99.5%	4.158
	97.5%	1.081
	90.0%	0.508
quartile	75.0%	0.266
median	50.0%	0.135
quartile	25.0%	0.073
	10.0%	0.033
	2.5%	0.005
	0.5%	0.002
minimum	0.0%	0.000

Moments	
Mean	0.28
Std Dev	0.85
Std Error Mean	0.00
Upper 95% Mean	0.28
Lower 95% Mean	0.27
N	32559.00
Sum Weights	32559.00

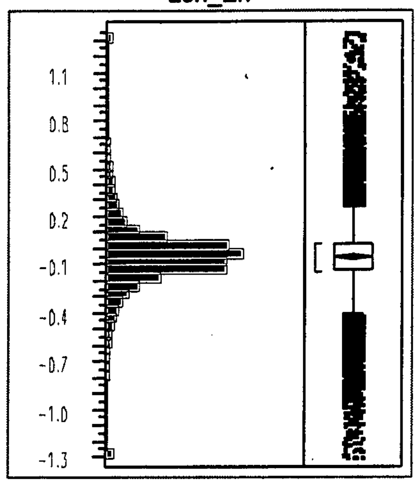
Figure A.2- 11 Histogram and Quantile for Horizontal Error and Look Ahead Time 0 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	22.878
	99.5%	1.382
	97.5%	0.403
	90.0%	0.139
quartile	75.0%	0.043
median	50.0%	-0.000
quartile	25.0%	-0.048
	10.0%	-0.150
	2.5%	-0.424
	0.5%	-1.278
minimum	0.0%	-15.570

Moments	
Mean	0.00
Std Dev	0.45
Std Error Mean	0.00
Upper 95% Mean	0.01
Lower 95% Mean	-0.00
N	32559.00
Sum Weights	32559.00

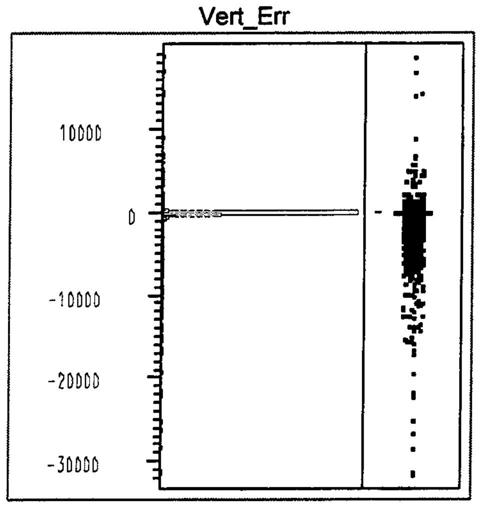
Figure A.2- 12 Histogram and Quantile for Lateral Error and Look Ahead Time 0 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	47.539
	99.5%	1.477
	97.5%	0.567
	90.0%	0.190
quartile	75.0%	0.037
median	50.0%	-0.044
quartile	25.0%	-0.134
	10.0%	-0.279
	2.5%	-0.634
	0.5%	-1.838
minimum	0.0%	-31.165

Moments	
Mean	-0.05
Std Dev	0.77
Std Error Mean	0.00
Upper 95% Mean	-0.04
Lower 95% Mean	-0.06
N	32559.00
Sum Weights	32559.00

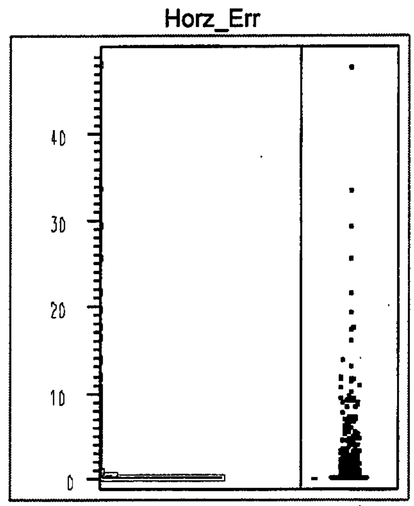
Figure A.2- 13 Histogram and Quantile for Longitudinal Error and Look Ahead Time 0 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	18889
	99.5%	553
	97.5%	195
	90.0%	93
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-42
	10.0%	-201
	2.5%	-866
	0.5%	-4311
minimum	0.0%	-31467

Moments	
Mean	-98.73
Std Dev	788.43
Std Error Mean	4.37
Upper 95% Mean	-90.16
Lower 95% Mean	-107.29
N	32559.00
Sum Weights	32559.00

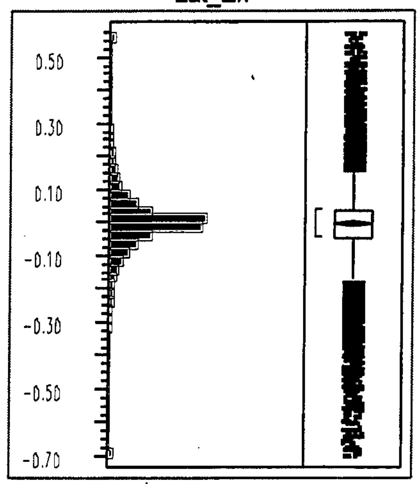
Figure A.2- 14 Histogram and Quantile for Vertical Error and Look Ahead Time 0 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	48.025
	99.5%	2.855
	97.5%	0.919
	90.0%	0.495
quartile	75.0%	0.253
median	50.0%	0.134
quartile	25.0%	0.077
	10.0%	0.033
	2.5%	0.005
	0.5%	0.002
minimum	0.0%	0.000

Moments	
Mean	0.25
Std Dev	0.75
Std Error Mean	0.01
Upper 95% Mean	0.26
Lower 95% Mean	0.24
N	21165.00
Sum Weights	21165.00

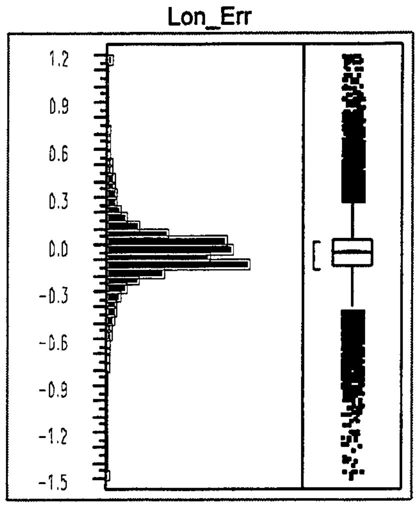
Figure A.2- 15 Histogram and Quantile for Horizontal Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	22.878
	99.5%	0.856
	97.5%	0.354
	90.0%	0.127
quartile	75.0%	0.040
median	50.0%	-0.000
quartile	25.0%	-0.045
	10.0%	-0.136
	2.5%	-0.368
	0.5%	-0.992
minimum	0.0%	-15.570

Moments	
Mean	-0.00
Std Dev	0.41
Std Error Mean	0.00
Upper 95% Mean	0.00
Lower 95% Mean	-0.01
N	21165.00
Sum Weights	21165.00

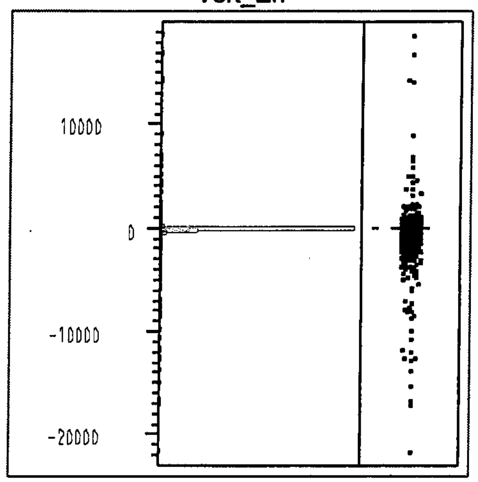
Figure A.2- 16 Histogram and Quantile for Lateral Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	47.539
	99.5%	1.278
	97.5%	0.575
	90.0%	0.181
quartile	75.0%	0.037
median	50.0%	-0.047
quartile	25.0%	-0.136
	10.0%	-0.263
	2.5%	-0.605
	0.5%	-1.118
minimum	0.0%	-31.165

Moments	
Mean	-0.04
Std Dev	0.68
Std Error Mean	0.00
Upper 95% Mean	-0.04
Lower 95% Mean	-0.05
N	21165.00
Sum Weights	21165.00

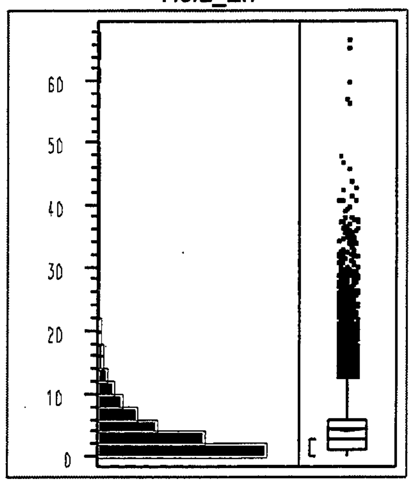
Figure A.2- 17 Histogram and Quantile for Longitudinal Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	18889
	99.5%	563
	97.5%	196
	90.0%	67
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	0
	10.0%	-100
	2.5%	-292
	0.5%	-1125
minimum	0.0%	-21500

Moments	
Mean	-17.53
Std Dev	500.09
Std Error Mean	3.44
Upper 95% Mean	-10.79
Lower 95% Mean	-24.27
N	21165.00
Sum Weights	21165.00

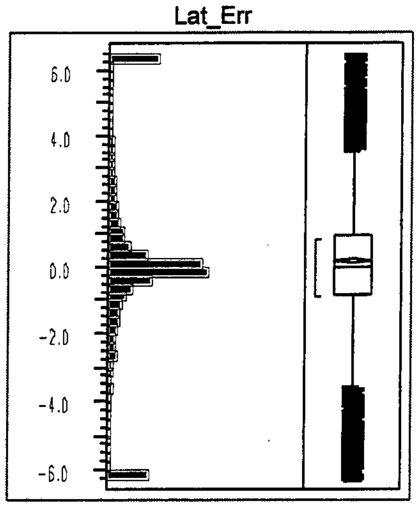
Figure A.2- 18 Histogram and Quantile for Vertical Error and Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	67.078
	99.5%	28.331
	97.5%	18.050
	90.0%	10.460
quartile	75.0%	6.078
median	50.0%	2.851
quartile	25.0%	1.304
	10.0%	0.599
	2.5%	0.230
	0.5%	0.094
minimum	0.0%	0.012

Moments	
Mean	4.53
Std Dev	4.95
Std Error Mean	0.03
Upper 95% Mean	4.59
Lower 95% Mean	4.46
N	21879.00
Sum Weights	21879.00

Figure A.2- 19 Histogram and Quantile for Horizontal Error and Look Ahead Time 600 for Samples at All Altitudes



Quantiles

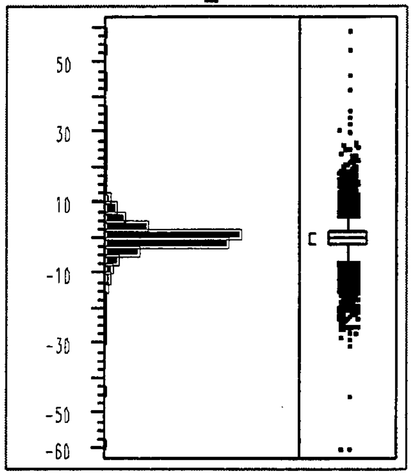
maximum	100.0%	55.499
	99.5%	22.137
	97.5%	12.308
	90.0%	4.611
quartile	75.0%	0.975
median	50.0%	-0.001
quartile	25.0%	-0.820
	10.0%	-3.807
	2.5%	-9.991
	0.5%	-19.225
minimum	0.0%	-38.275

Moments

Mean	0.24
Std Dev	5.03
Std Error Mean	0.03
Upper 95% Mean	0.30
Lower 95% Mean	0.17
N	21879.00
Sum Weights	21879.00

Figure A.2- 20 Histogram and Quantile for Lateral Error and Look Ahead Time 600 for Samples at All Altitudes

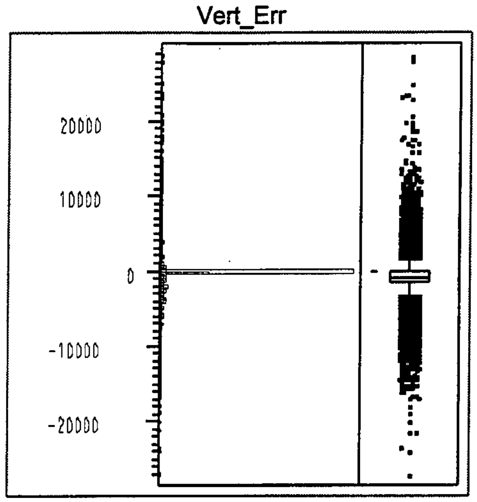
Lon_Err



	Quantiles	
maximum	100.0%	59.630
	99.5%	16.290
	97.5%	9.523
	90.0%	4.909
quartile	75.0%	1.945
median	50.0%	0.204
quartile	25.0%	-1.359
	10.0%	-3.911
	2.5%	-9.361
	0.5%	-15.604
minimum	0.0%	-59.561

Moments	
Mean	0.29
Std Dev	4.43
Std Error Mean	0.03
Upper 95% Mean	0.35
Lower 95% Mean	0.24
N	21879.00
Sum Weights	21879.00

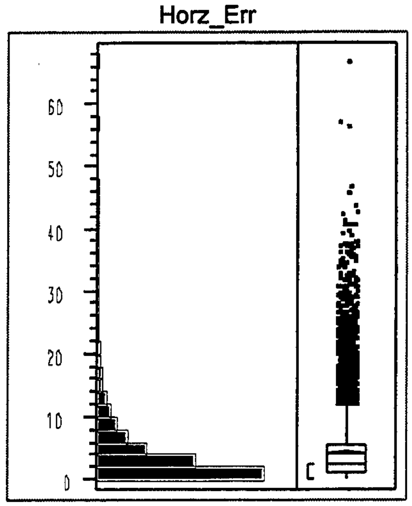
Figure A.2- 21 Histogram and Quantile for Longitudinal Error and Look Ahead Time 600 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	28990
	99.5%	9362
	97.5%	4200
	90.0%	680
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-1264
	10.0%	-4210
	2.5%	-7683
	0.5%	-11096
minimum	0.0%	-26868

Moments	
Mean	-759.30
Std Dev	2843.26
Std Error Mean	19.22
Upper 95% Mean	-721.62
Lower 95% Mean	-796.97
N	21879.00
Sum Weights	21879.00

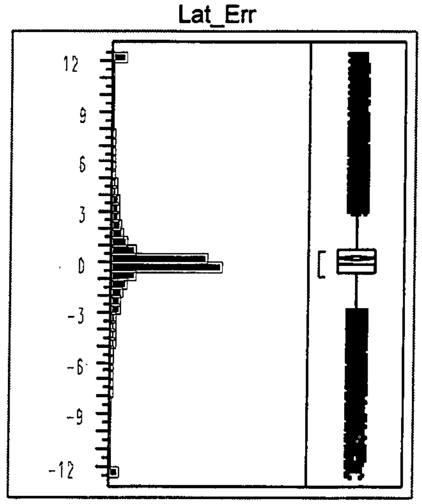
Figure A.2- 22 Histogram and Quantile for Vertical Error and Look Ahead Time 600 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	67.078
	99.5%	30.332
	97.5%	18.932
	90.0%	10.476
quartile	75.0%	5.697
median	50.0%	2.618
quartile	25.0%	1.191
	10.0%	0.542
	2.5%	0.209
	0.5%	0.078
minimum	0.0%	0.012

Moments	
Mean	4.41
Std Dev	5.16
Std Error Mean	0.04
Upper 95% Mean	4.50
Lower 95% Mean	4.33
N	14781.00
Sum Weights	14781.00

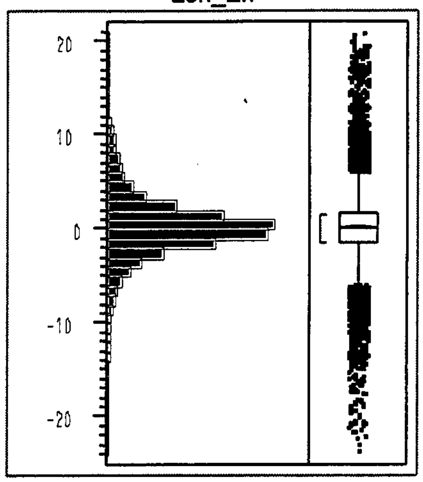
Figure A.2- 23 Histogram and Quantile for Horizontal Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	55.499
	99.5%	25.207
	97.5%	13.303
	90.0%	4.808
quartile	75.0%	0.875
median	50.0%	-0.001
quartile	25.0%	-0.589
	10.0%	-3.741
	2.5%	-10.708
	0.5%	-20.190
minimum	0.0%	-38.275

Moments	
Mean	0.33
Std Dev	5.36
Std Error Mean	0.04
Upper 95% Mean	0.41
Lower 95% Mean	0.24
N	14781.00
Sum Weights	14781.00

Figure A.2- 24 Histogram and Quantile for Lateral Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

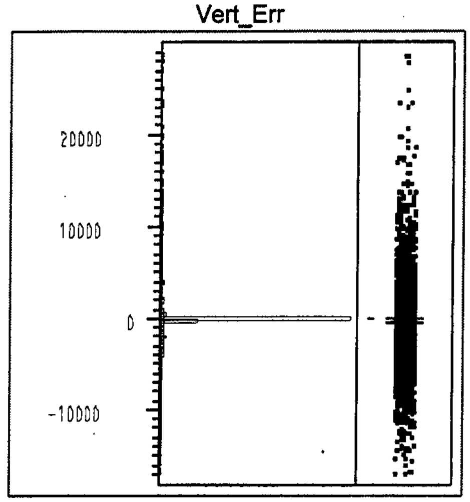


	Quantiles	
maximum	100.0%	59.630
	99.5%	17.181
	97.5%	9.452
	90.0%	4.290
quartile	75.0%	1.737
median	50.0%	0.164
quartile	25.0%	-1.309
	10.0%	-3.449
	2.5%	-8.064
	0.5%	-13.862
minimum	0.0%	-29.720

Moments	
Mean	0.32
Std Dev	4.13
Std Error Mean	0.03
Upper 95% Mean	0.38
Lower 95% Mean	0.25
N	14781.00
Sum Weights	14781.00

Figure A.2- 25 Histogram and Quantile for Longitudinal Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Vert_Err



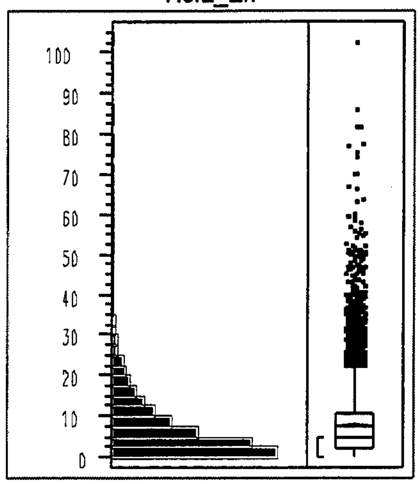
Quantiles

maximum	100.0%	28990
	99.5%	10602
	97.5%	4810
	90.0%	1000
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-19
	10.0%	-3083
	2.5%	-6588
	0.5%	-10171
minimum	0.0%	-16708

Moments

Mean	-285.52
Std Dev	2596.63
Std Error Mean	21.36
Upper 95% Mean	-243.66
Lower 95% Mean	-327.39
N	14781.00
Sum Weights	14781.00

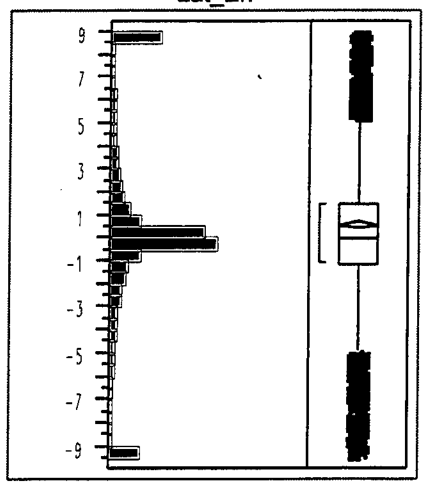
Figure A.2- 26 Histogram and Quantile for Vertical Error and Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	103.04
	99.5%	45.67
	97.5%	28.82
	90.0%	18.21
quartile	75.0%	10.68
median	50.0%	5.08
quartile	25.0%	2.36
	10.0%	1.11
	2.5%	0.40
	0.5%	0.15
minimum	0.0%	0.01

Moments	
Mean	7.82
Std Dev	8.12
Std Error Mean	0.07
Upper 95% Mean	7.96
Lower 95% Mean	7.68
N	12906.00
Sum Weights	12906.00

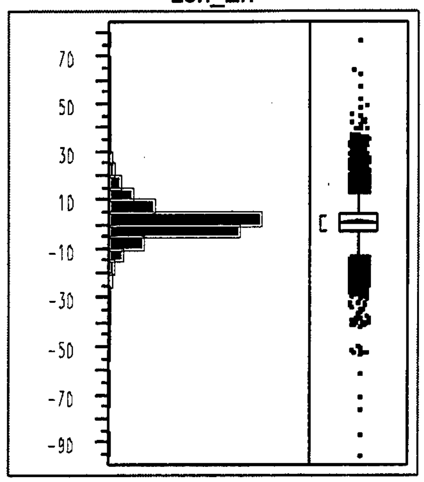
Figure A.2- 27 Histogram and Quantile for Horizontal Error and Look Ahead Time 1200 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	76.097
	99.5%	31.484
	97.5%	19.275
	90.0%	7.327
quartile	75.0%	1.434
median	50.0%	0.003
quartile	25.0%	-1.103
	10.0%	-5.291
	2.5%	-13.911
	0.5%	-27.595
minimum	0.0%	-55.557

Moments	
Mean	0.56
Std Dev	7.46
Std Error Mean	0.07
Upper 95% Mean	0.69
Lower 95% Mean	0.43
N	12906.00
Sum Weights	12906.00

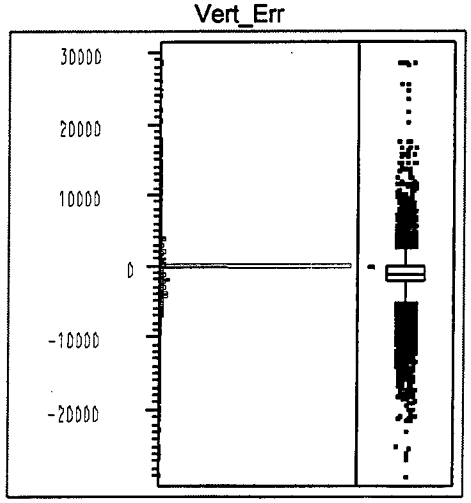
Figure A.2- 28 Histogram and Quantile for Lateral Error and Look Ahead Time 1200 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	77.593
	99.5%	33.079
	97.5%	20.209
	90.0%	10.599
quartile	75.0%	4.145
median	50.0%	0.678
quartile	25.0%	-2.332
	10.0%	-6.634
	2.5%	-14.954
	0.5%	-25.366
minimum	0.0%	-94.354

Moments	
Mean	1.20
Std Dev	8.35
Std Error Mean	0.07
Upper 95% Mean	1.34
Lower 95% Mean	1.05
N	12906.00
Sum Weights	12906.00

Figure A.2- 29 Histogram and Quantile for Longitudinal Error and Look Ahead Time 1200 for Samples at All Altitudes



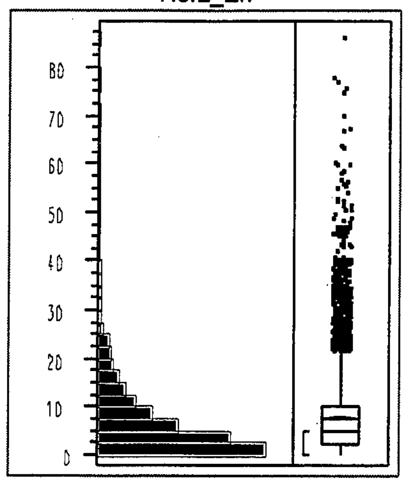
Quantiles

maximum	100.0%	29003
	99.5%	11400
	97.5%	4996
	90.0%	894
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-2000
	10.0%	-5533
	2.5%	-9956
	0.5%	-15000
minimum	0.0%	-28868

Moments

Mean	-1054.38
Std Dev	3582.30
Std Error Mean	31.53
Upper 95% Mean	-992.57
Lower 95% Mean	-1116.19
N	12906.00
Sum Weights	12906.00

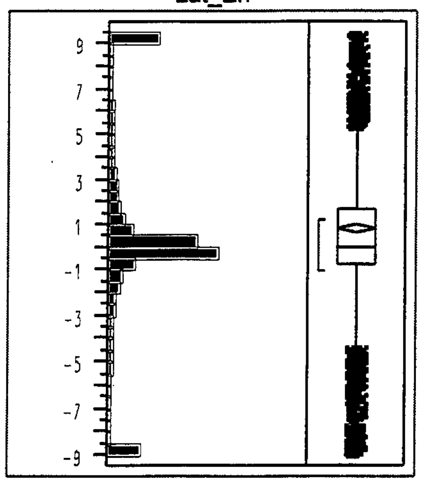
Figure A.2- 30 Histogram and Quantile for Vertical Error and Look Ahead Time 1200 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	86.730
	99.5%	46.966
	97.5%	31.471
	90.0%	18.739
quartile	75.0%	10.329
median	50.0%	4.878
quartile	25.0%	2.239
	10.0%	1.022
	2.5%	0.356
	0.5%	0.152
minimum	0.0%	0.010

Moments	
Mean	7.793
Std Dev	8.433
Std Error Mean	0.093
Upper 95% Mean	7.976
Lower 95% Mean	7.610
N	8174.000
Sum Weights	8174.000

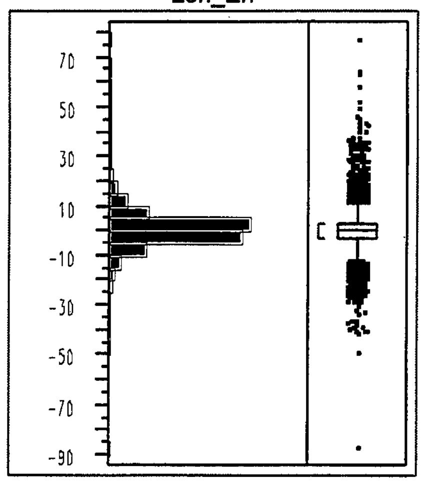
Figure A.2- 31 Histogram and Quantile for Horizontal Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	76.097
	99.5%	38.178
	97.5%	20.816
	90.0%	8.617
quartile	75.0%	1.685
median	50.0%	0.012
quartile	25.0%	-0.725
	10.0%	-5.491
	2.5%	-15.418
	0.5%	-29.866
minimum	0.0%	-55.557

Moments	
Mean	0.864
Std Dev	8.254
Std Error Mean	0.091
Upper 95% Mean	1.043
Lower 95% Mean	0.685
N	8174.000
Sum Weights	8174.000

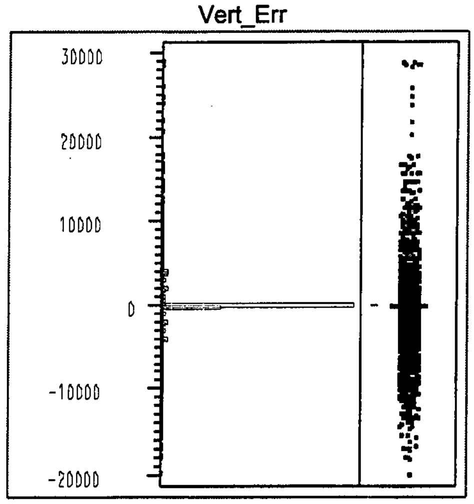
Figure A.2- 32 Histogram and Quantile for Lateral Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	77.593
	99.5%	34.644
	97.5%	18.449
	90.0%	8.733
quartile	75.0%	3.429
median	50.0%	0.314
quartile	25.0%	-2.606
	10.0%	-6.633
	2.5%	-14.938
	0.5%	-25.017
minimum	0.0%	-85.873

Moments	
Mean	0.710
Std Dev	7.904
Std Error Mean	0.087
Upper 95% Mean	0.881
Lower 95% Mean	0.538
N	8174.000
Sum Weights	8174.000

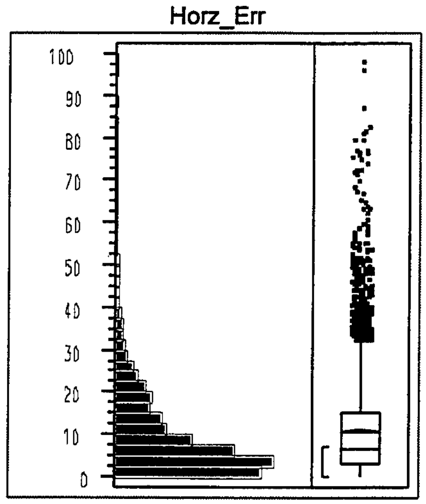
Figure A.2- 33 Histogram and Quantile for Longitudinal Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	29003
	99.5%	13987
	97.5%	5998
	90.0%	1990
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-12
	10.0%	-3328
	2.5%	-7014
	0.5%	-11663
minimum	0.0%	-19633

Moments	
Mean	-201.604
Std Dev	3063.830
Std Error Mean	33.888
Upper 95% Mean	-135.174
Lower 95% Mean	-268.035
N	8174.000
Sum Weights	8174.000

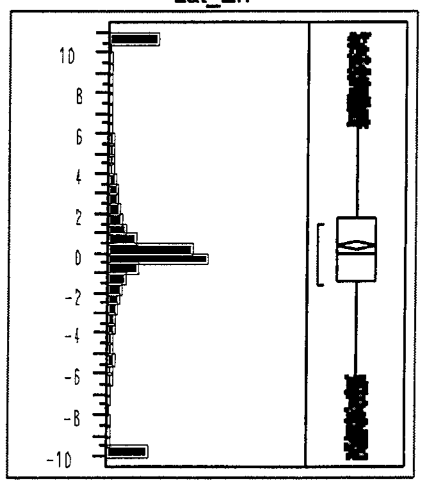
Figure A.2- 34 Histogram and Quantile for Vertical Error and Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	98.819
	99.5%	60.160
	97.5%	41.289
	90.0%	25.177
quartile	75.0%	15.152
median	50.0%	6.972
quartile	25.0%	3.265
	10.0%	1.511
	2.5%	0.539
	0.5%	0.202
minimum	0.0%	0.033

Moments	
Mean	10.944
Std Dev	11.221
Std Error Mean	0.138
Upper 95% Mean	11.214
Lower 95% Mean	10.674
N	6652.000
Sum Weights	6652.000

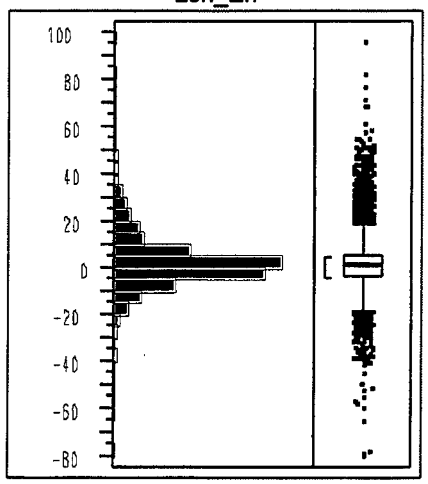
Figure A.2- 35 Histogram and Quantile for Horizontal Error and Look Ahead Time 1800 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	86.540
	99.5%	38.179
	97.5%	20.862
	90.0%	8.903
quartile	75.0%	1.800
median	50.0%	0.001
quartile	25.0%	-1.327
	10.0%	-6.680
	2.5%	-19.617
	0.5%	-36.906
minimum	0.0%	-62.208

	Moments	
Mean		0.455
Std Dev		9.395
Std Error Mean		0.115
Upper 95% Mean		0.681
Lower 95% Mean		0.229
N		6652.000
Sum Weights		6652.000

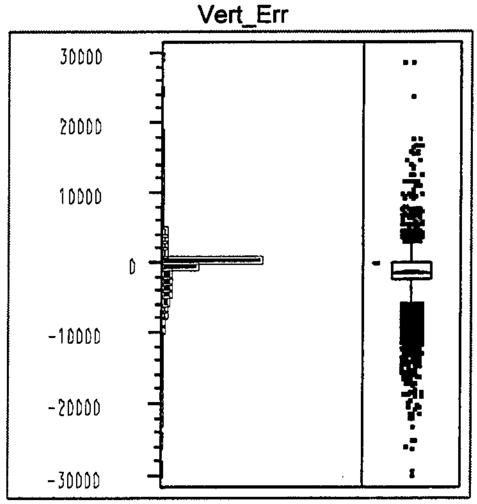
Figure A.2- 36 Histogram and Quantile for Lateral Error and Look Ahead Time 1800 for Samples at All Altitudes



	Quantiles	
maximum	100.0%	96.864
	99.5%	50.147
	97.5%	32.840
	90.0%	17.798
quartile	75.0%	6.068
median	50.0%	1.039
quartile	25.0%	-3.394
	10.0%	-9.044
	2.5%	-19.133
	0.5%	-36.379
minimum	0.0%	-78.603

Moments	
Mean	2.433
Std Dev	12.300
Std Error Mean	0.151
Upper 95% Mean	2.728
Lower 95% Mean	2.137
N	6652.000
Sum Weights	6652.000

Figure A.2- 37 Histogram and Quantile for Longitudinal Error and Look Ahead Time 1800 for Samples at All Altitudes

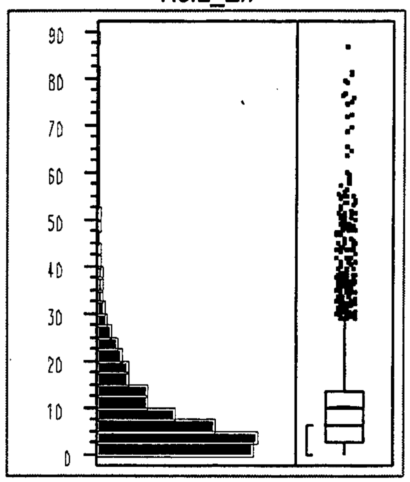


	Quantiles	
maximum	100.0%	29003
	99.5%	10171
	97.5%	4183
	90.0%	1000
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-2217
	10.0%	-6283
	2.5%	-11092
	0.5%	-16573
minimum	0.0%	-29635

Moments	
Mean	-1267.540
Std Dev	3870.108
Std Error Mean	47.451
Upper 95% Mean	-1174.519
Lower 95% Mean	-1360.561
N	6652.000
Sum Weights	6652.000

Figure A.2- 38 Histogram and Quantile for Vertical Error and Look Ahead Time 1800 for Samples at All Altitudes

Horz_Err



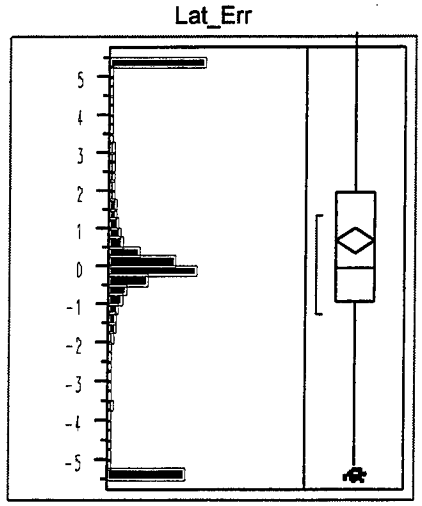
Quantiles

maximum	100.0%	87.650
	99.5%	59.734
	97.5%	43.374
	90.0%	23.817
quartile	75.0%	13.729
median	50.0%	6.567
quartile	25.0%	3.048
	10.0%	1.401
	2.5%	0.476
	0.5%	0.167
minimum	0.0%	0.033

Moments

Mean	10.348
Std Dev	11.088
Std Error Mean	0.177
Upper 95% Mean	10.696
Lower 95% Mean	10.001
N	3912.000
Sum Weights	3912.000

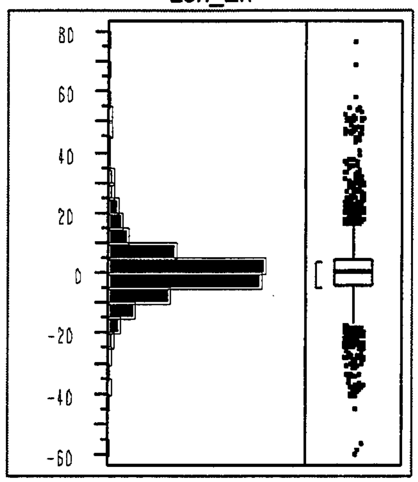
Figure A.2- 39 Histogram and Quantile for Horizontal Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	86.540
	99.5%	49.046
	97.5%	21.972
	90.0%	10.498
quartile	75.0%	1.948
median	50.0%	-0.004
quartile	25.0%	-0.898
	10.0%	-7.210
	2.5%	-21.145
	0.5%	-42.319
minimum	0.0%	-62.208

Moments	
Mean	0.708
Std Dev	10.332
Std Error Mean	0.165
Upper 95% Mean	1.032
Lower 95% Mean	0.384
N	3912.000
Sum Weights	3912.000

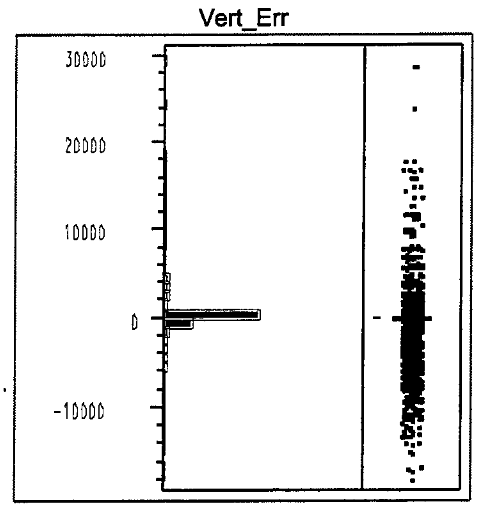
Figure A.2- 40 Histogram and Quantile for Lateral Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	77.472
	99.5%	51.686
	97.5%	28.083
	90.0%	10.933
quartile	75.0%	4.550
median	50.0%	0.232
quartile	25.0%	-3.971
	10.0%	-9.537
	2.5%	-19.839
	0.5%	-36.939
minimum	0.0%	-58.652

Moments	
Mean	0.844
Std Dev	11.049
Std Error Mean	0.177
Upper 95% Mean	1.191
Lower 95% Mean	0.498
N	3912.000
Sum Weights	3912.000

Figure A.2- 41 Histogram and Quantile for Longitudinal Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



	Quantiles	
maximum	100.0%	29003
	99.5%	12994
	97.5%	5983
	90.0%	2638
quartile	75.0%	0
median	50.0%	0
quartile	25.0%	-6
	10.0%	-3000
	2.5%	-8085
	0.5%	-12354
minimum	0.0%	-17851

Moments	
Mean	-129.068
Std Dev	3060.423
Std Error Mean	48.931
Upper 95% Mean	-33.134
Lower 95% Mean	-225.001
N	3912.000
Sum Weights	3912.000

Figure A.2- 42 Histogram and Quantile for Vertical Error and Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

A.2.2 Flight Type Per Look Ahead Time

A.2.2.1 Summary Tables

LOOKAHEAD TIME			0 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	9811	9698	9424	3626
Avg. Horz. Error	0.24	0.31	0.25	0.33
Stddev. Horz. Error	0.91	0.81	0.61	1.23
Max. Horz. Error	48.02	19.85	21.86	33.7
Min. Horz. Error	0	0	0	0
Avg. Lat. Error	0	0	-0.01	0.02
Stddev. Lat. Error	0.34	0.52	0.39	0.65
Max. Lat. Error	22.88	18.66	10.75	13.61
Min. Lat. Error	-3.72	-15.57	-11.26	-5.34
Avg. Abs. Lat. Error	0.09	0.16	0.11	0.17
Stddev. Abs. Lat. Error	0.33	0.49	0.37	0.63
Max. Abs. Lat. Error	22.88	18.66	11.26	13.61
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.06	-0.05	-0.03	-0.08
Stddev. Long. Error	0.87	0.69	0.53	1.1
Max. Long. Error	47.54	14.47	11.54	16.44
Min. Long. Error	-23.09	-13.58	-21.17	-31.16
Avg. Abs. Long. Error	0.2	0.22	0.19	0.25
Stddev. Abs. Long. Error	0.85	0.66	0.49	1.07
Max. Abs. Long. Error	47.54	14.47	21.17	31.16
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-26.65	-136.85	-86.47	-223.64
Stddev. Vert. Error	628.2	767.97	839.17	1035.82
Max. Vert. Error	17000	5200	7125	18889
Min. Vert. Error	-26348	-15565.9	-31466.5	-13425
Avg. Abs. Vert. Error	64.75	187.89	147.88	319.91
Stddev. Abs. Vert. Error	625.42	757.1	830.55	1010.24
Max. Abs. Vert. Error	26348	15565.91	31466.46	18889
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	0.24	0.32	0.26	0.35
Stddev. Slant Range Error	0.91	0.82	0.62	1.24
Max. Slant Range Error	48.03	19.91	21.87	33.78
Min. Slant Range Error	0	0	0	0

Figure A.2- 43 Descriptive Statistics for Flight Types at Look Ahead Time of 0 and Samples at All Altitudes

LOOKAHEAD TIME		300 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	8358	8055	7739	2971
Avg. Horz. Error	1.85	3.03	2.89	3.14
Stddev. Horz. Error	2.61	3.34	3.19	3.82
Max. Horz. Error	46.09	55.05	33.37	88.45
Min. Horz. Error	0	0.01	0.01	0.03
Avg. Lat. Error	-0.06	-0.06	0.19	0.08
Stddev. Lat. Error	2.49	3.72	3.58	3.32
Max. Lat. Error	27.04	46.61	32.28	29.48
Min. Lat. Error	-22.88	-46.12	-25.39	-36.48
Avg. Abs. Lat. Error	1.1	2.14	1.94	1.88
Stddev. Abs. Lat. Error	2.24	3.05	3.02	2.73
Max. Abs. Lat. Error	27.04	46.61	32.28	36.48
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.06	-0.1	0.02	-0.17
Stddev. Long. Error	2	2.55	2.38	3.66
Max. Long. Error	46.01	22.74	15.07	17.54
Min. Long. Error	-27.41	-29.29	-22.36	-87.99
Avg. Abs. Long. Error	1.11	1.6	1.59	1.94
Stddev. Abs. Long. Error	1.67	1.99	1.77	3.1
Max. Abs. Long. Error	46.01	29.29	22.36	87.99
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-56.9	-1018.42	-362.16	-955.35
Stddev. Vert. Error	1148.48	2461.8	2084.76	3104.14
Max. Vert. Error	17000	13350	13961	27290
Min. Vert. Error	-17800	-17950	-24677	-14639
Avg. Abs. Vert. Error	309.08	1532.73	1065.32	1896.9
Stddev. Abs. Vert. Error	1107.57	2179.04	1828.21	2636.14
Max. Abs. Vert. Error	17800	17950	24677	27290
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	1.86	3.07	2.91	3.19
Stddev. Slant Range Error	2.61	3.33	3.19	3.81
Max. Slant Range Error	46.09	55.05	33.37	88.56
Min. Slant Range Error	0.01	0.01	0.01	0.03

Figure A.2- 44 Descriptive Statistics for Flight Types at Look Ahead Time of 300 and Samples at All Altitudes

LOOKAHEAD TIME			600 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	6964	6410	6127	2378
Avg. Horz. Error	3.26	4.81	5.35	5.33
Stddev. Horz. Error	4.41	4.73	5.48	4.89
Max. Horz. Error	56.87	67.08	65.69	36.75
Min. Horz. Error	0.01	0.02	0.01	0.04
Avg. Lat. Error	-0.06	-0.07	0.86	0.33
Stddev. Lat. Error	4.23	4.89	5.96	4.82
Max. Lat. Error	55.5	33.84	38.94	33.12
Min. Lat. Error	-34.77	-38.27	-32.29	-33.24
Avg. Abs. Lat. Error	1.81	2.93	3.28	2.78
Stddev. Abs. Lat. Error	3.82	3.92	5.04	3.95
Max. Abs. Lat. Error	55.5	38.27	38.94	33.24
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.02	0.23	0.46	0.82
Stddev. Long. Error	3.49	4.64	4.72	5.32
Max. Long. Error	46.83	59.63	30.58	34.91
Min. Long. Error	-28	-59.4	-59.56	-26.29
Avg. Abs. Long. Error	2.04	3.02	3.19	3.66
Stddev. Abs. Long. Error	2.83	3.53	3.51	3.95
Max. Abs. Long. Error	46.83	59.63	59.56	34.91
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-106.29	-1923.41	-140.57	-1127.88
Stddev. Vert. Error	1577.38	3217.9	2691.21	3808.73
Max. Vert. Error	17000	17800	23878	28990
Min. Vert. Error	-16406.8	-26868	-14510	-14944.7
Avg. Abs. Vert. Error	476.56	2388.78	1395.55	2406.97
Stddev. Abs. Vert. Error	1507.41	2889.25	2305.32	3159.6
Max. Abs. Vert. Error	17000	26868	23878	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	3.28	4.87	5.38	5.38
Stddev. Slant Range Error	4.41	4.71	5.48	4.88
Max. Slant Range Error	56.87	67.09	65.69	36.75
Min. Slant Range Error	0.01	0.03	0.01	0.04

Figure A.2- 45 Descriptive Statistics for Flight Types at Look Ahead Time of 600 and Samples at All Altitudes

LOOKAHEAD TIME		900 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	5655	4791	4629	1846
Avg. Horz. Error	4.66	6.22	7.54	7.58
Stddev. Horz. Error	6.17	5.88	7.06	7.04
Max. Horz. Error	62.17	86.49	101.09	75.25
Min. Horz. Error	0.01	0.02	0.03	0.05
Avg. Lat. Error	-0.01	-0.06	1.63	0.34
Stddev. Lat. Error	5.9	5.33	7.65	5.97
Max. Lat. Error	60.84	32.02	54.78	42.67
Min. Lat. Error	-39.76	-38.45	-64.27	-43.96
Avg. Abs. Lat. Error	2.49	3.23	4.45	3.4
Stddev. Abs. Lat. Error	5.35	4.25	6.44	4.92
Max. Abs. Lat. Error	60.84	38.45	64.27	43.96
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.15	0.69	0.65	2.01
Stddev. Long. Error	5	6.67	6.72	8.2
Max. Long. Error	37.39	58.31	30.21	49.55
Min. Long. Error	-31.86	-83.04	-78.02	-61.99
Avg. Abs. Long. Error	3	4.39	4.65	5.69
Stddev. Abs. Long. Error	4	5.07	4.88	6.24
Max. Abs. Long. Error	37.39	83.04	78.02	61.99
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-154.69	-2586.96	56.28	-1322.46
Stddev. Vert. Error	1947.04	3795.44	3083.09	4361.4
Max. Vert. Error	17000	17747	29003	28990
Min. Vert. Error	-20550	-32426	-17600	-14560.4
Avg. Abs. Vert. Error	613.01	3059.18	1499.78	2796.43
Stddev. Abs. Vert. Error	1854.47	3426.17	2694.21	3598.25
Max. Abs. Vert. Error	20550	32426	29003	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	4.68	6.3	7.57	7.63
Stddev. Slant Range Error	6.17	5.85	7.05	7.03
Max. Slant Range Error	62.17	86.49	101.09	75.4
Min. Slant Range Error	0.01	0.04	0.05	0.05

Figure A.2- 46 Descriptive Statistics for Flight Types at Look Ahead Time of 900 and Samples at All Altitudes

LOOKAHEAD TIME		1200 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	4484	3585	3426	1411
Avg. Horz. Error	6.09	7.58	9.57	9.72
Stddev. Horz. Error	7.92	7.04	8.45	9.15
Max. Horz. Error	78.4	63.92	103.04	86.73
Min. Horz. Error	0.03	0.02	0.01	0.09
Avg. Lat. Error	-0.02	0.02	2.18	-0.15
Stddev. Lat. Error	7.37	5.92	8.91	6.78
Max. Lat. Error	76.1	36.69	53.39	41.78
Min. Lat. Error	-55.56	-38.88	-49.48	-50.89
Avg. Abs. Lat. Error	3.11	3.53	5.4	3.88
Stddev. Abs. Lat. Error	6.68	4.76	7.41	5.56
Max. Abs. Lat. Error	76.1	38.88	53.39	50.89
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.37	1.39	1.12	3.55
Stddev. Long. Error	6.73	8.37	8.81	10.94
Max. Long. Error	38.33	63.92	44.46	77.59
Min. Long. Error	-40.8	-38.96	-94.35	-85.87
Avg. Abs. Long. Error	4.03	5.64	6.21	7.71
Stddev. Abs. Long. Error	5.4	6.34	6.35	8.53
Max. Abs. Long. Error	40.8	63.92	94.35	85.87
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-209.47	-2970.29	68.13	-1597.06
Stddev. Vert. Error	2166.89	4031.85	3271.64	4499.37
Max. Vert. Error	17000	15000	29003	28990
Min. Vert. Error	-25050	-28868	-24801	-16582.5
Avg. Abs. Vert. Error	711.38	3444.47	1542.73	3014.31
Stddev. Abs. Vert. Error	2057.46	3635	2885.76	3701.93
Max. Abs. Vert. Error	25050	28868	29003	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	6.1	7.66	9.6	9.77
Stddev. Slant Range Error	7.92	7.01	8.44	9.13
Max. Slant Range Error	78.4	63.95	103.05	86.86
Min. Slant Range Error	0.03	0.08	0.01	0.09

Figure A.2- 47 Descriptive Statistics for Flight Types at Look Ahead Time of 1200 and Samples at All Altitudes

LOOKAHEAD TIME		1500 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	3498	2394	2355	1005
Avg. Horz. Error	7.49	9.09	11.3	12.36
Stddev. Horz. Error	9.66	8.64	9.6	11.33
Max. Horz. Error	87.22	74.04	92.1	94.14
Min. Horz. Error	0.03	0.13	0.09	0.17
Avg. Lat. Error	-0.07	0.13	2.19	-0.91
Stddev. Lat. Error	8.84	6.64	9.87	7.62
Max. Lat. Error	85.67	30.91	67.1	42.67
Min. Lat. Error	-65.63	-44.45	-55.21	-58.18
Avg. Abs. Lat. Error	3.72	3.91	5.97	4.39
Stddev. Abs. Lat. Error	8.02	5.37	8.16	6.29
Max. Abs. Lat. Error	85.67	44.45	67.1	58.18
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.63	2.51	1.51	5.42
Stddev. Long. Error	8.43	10.34	10.74	13.9
Max. Long. Error	47.19	74.04	61.01	94.14
Min. Long. Error	-49.89	-45.02	-73.71	-64.82
Avg. Abs. Long. Error	5.05	6.99	7.75	10.15
Stddev. Abs. Long. Error	6.77	8.02	7.58	10.92
Max. Abs. Long. Error	49.89	74.04	73.71	94.14
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-298.32	-3329.51	90.46	-1849.84
Stddev. Vert. Error	2331.38	4341.96	3310.21	4306.76
Max. Vert. Error	17000	10600	29003	28990
Min. Vert. Error	-22800	-27901	-24904	-18609
Avg. Abs. Vert. Error	811.85	3809.9	1565.11	3120.37
Stddev. Abs. Vert. Error	2205.69	3927.02	2918.06	3496.73
Max. Abs. Vert. Error	22800	27901	29003	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	7.51	9.17	11.32	12.42
Stddev. Slant Range Error	9.66	8.6	9.59	11.3
Max. Slant Range Error	87.23	74.04	92.1	94.14
Min. Slant Range Error	0.03	0.16	0.09	0.2

Figure A.2- 48 Descriptive Statistics for Flight Types at Look Ahead Time of 1500 and Samples at All Altitudes

LOOKAHEAD TIME			1800 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	2714	1634	1567	737
Avg. Horz. Error	8.85	11.02	12.6	14.96
Stddev. Horz. Error	11.12	10.48	10.48	12.91
Max. Horz. Error	87.65	73.08	98.82	96.9
Min. Horz. Error	0.06	0.03	0.03	0.19
Avg. Lat. Error	0.05	0.46	2.07	-1.51
Stddev. Lat. Error	9.85	8.02	10.09	8.38
Max. Lat. Error	86.54	37.65	64.33	54.57
Min. Lat. Error	-62.21	-45.06	-59.89	-42.31
Avg. Abs. Lat. Error	4.26	4.65	6.05	5.09
Stddev. Abs. Lat. Error	8.89	6.55	8.34	6.82
Max. Abs. Lat. Error	86.54	45.06	64.33	54.57
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.95	3.68	1.35	7.4
Stddev. Long. Error	10.2	12.37	12.68	16.23
Max. Long. Error	55.83	72.38	77.47	96.86
Min. Long. Error	-58.65	-50.4	-78.6	-77.43
Avg. Abs. Long. Error	6.08	8.56	9.16	12.53
Stddev. Abs. Long. Error	8.24	9.67	8.87	12.7
Max. Abs. Long. Error	58.65	72.38	78.6	96.86
Min. Abs. Long. Error	0	0	0	0.05
Avg. Vert. Error	-366.26	-3766.65	189.57	-2143.8
Stddev. Vert. Error	2399.37	4706.02	3381.19	4302.9
Max. Vert. Error	17000	10300	29003	24000
Min. Vert. Error	-21800	-29635	-19867	-19613
Avg. Abs. Vert. Error	888.46	4240.85	1655	3347.76
Stddev. Abs. Vert. Error	2258.65	4283.35	2954.25	3448.81
Max. Abs. Vert. Error	21800	29635	29003	24000
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	8.86	11.1	12.62	15.01
Stddev. Slant Range Error	11.12	10.44	10.48	12.88
Max. Slant Range Error	87.65	73.08	98.82	96.91
Min. Slant Range Error	0.06	0.24	0.03	0.19

Figure A.2- 49 Descriptive Statistics for Flight Types at Look Ahead Time of 1800 and Samples at All Altitudes

LOOKAHEAD TIME			0 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	8622	5944	5764	835
Avg. Horz. Error	0.23	0.25	0.26	0.36
Stddev. Horz. Error	0.82	0.44	0.69	1.68
Max. Horz. Error	48.02	17.72	21.86	33.7
Min. Horz. Error	0	0	0	0
Avg. Lat. Error	0	-0.02	-0.01	0.07
Stddev. Lat. Error	0.35	0.38	0.4	0.94
Max. Lat. Error	22.88	8.7	10.75	13.61
Min. Lat. Error	-3.72	-15.57	-10.95	-3.27
Avg. Abs. Lat. Error	0.09	0.13	0.11	0.19
Stddev. Abs. Lat. Error	0.34	0.36	0.38	0.93
Max. Abs. Lat. Error	22.88	15.57	10.95	13.61
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.04	-0.06	-0.02	-0.17
Stddev. Long. Error	0.77	0.32	0.62	1.43
Max. Long. Error	47.54	3.56	11.54	1.81
Min. Long. Error	-23.09	-8.47	-21.17	-31.16
Avg. Abs. Long. Error	0.19	0.17	0.2	0.27
Stddev. Abs. Long. Error	0.75	0.28	0.58	1.41
Max. Abs. Long. Error	47.54	8.47	21.17	31.16
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-9.52	-28.34	-27.11	42.84
Stddev. Vert. Error	478.37	251.04	560.78	1163.2
Max. Vert. Error	17000	5200	7125	18889
Min. Vert. Error	-16406.8	-5451	-21500	-11438
Avg. Abs. Vert. Error	44.64	76.9	94.69	174.86
Stddev. Abs. Vert. Error	476.38	240.64	553.39	1150.77
Max. Abs. Vert. Error	17000	5451	21500	18889
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	0.23	0.25	0.26	0.37
Stddev. Slant Range Error	0.82	0.44	0.69	1.69
Max. Slant Range Error	48.03	17.73	21.87	33.78
Min. Slant Range Error	0	0	0	0

Figure A.2- 50 Descriptive Statistics for Flight Types at Look Ahead Time of 0 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME		300 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	7337	4728	5599	751
Avg. Horz. Error	1.84	2.89	2.89	3.68
Stddev. Horz. Error	2.62	3.56	3.25	5.97
Max. Horz. Error	46.09	55.05	33.37	88.45
Min. Horz. Error	0	0.01	0.01	0.03
Avg. Lat. Error	-0.07	-0.19	0.44	0.05
Stddev. Lat. Error	2.56	4.05	3.68	4.79
Max. Lat. Error	27.04	46.61	32.28	29.48
Min. Lat. Error	-22.88	-46.12	-22.33	-36.48
Avg. Abs. Lat. Error	1.1	2.24	1.96	2.49
Stddev. Abs. Lat. Error	2.32	3.37	3.15	4.09
Max. Abs. Lat. Error	27.04	46.61	32.28	36.48
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.04	-0.03	0.23	-0.07
Stddev. Long. Error	1.91	2.13	2.27	5.13
Max. Long. Error	46.01	17.18	15.07	16.44
Min. Long. Error	-27.41	-29.29	-16.41	-87.99
Avg. Abs. Long. Error	1.08	1.3	1.54	1.96
Stddev. Abs. Long. Error	1.57	1.69	1.68	4.73
Max. Abs. Long. Error	46.01	29.29	16.41	87.99
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	4.41	-556.71	-52.77	337.43
Stddev. Vert. Error	982.18	2195.66	1714.12	3794.84
Max. Vert. Error	17000	13350	13961	27290
Min. Vert. Error	-16146	-17950	-18228	-14133
Avg. Abs. Vert. Error	241.3	1147.69	891.7	1806.59
Stddev. Abs. Vert. Error	952.09	1952.8	1464.83	3353.6
Max. Abs. Vert. Error	17000	17950	18228	27290
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	1.84	2.92	2.91	3.73
Stddev. Slant Range Error	2.62	3.55	3.25	5.98
Max. Slant Range Error	46.09	55.05	33.37	88.56
Min. Slant Range Error	0.01	0.01	0.01	0.03

Figure A.2- 51 Descriptive Statistics for Flight Types at Look Ahead Time of 300 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME			600 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	6069	3524	4601	587
Avg. Horz. Error	3.28	4.45	5.63	6.36
Stddev. Horz. Error	4.53	4.83	5.62	6.42
Max. Horz. Error	56.87	67.08	44.23	36.75
Min. Horz. Error	0.01	0.02	0.01	0.1
Avg. Lat. Error	-0.09	-0.23	1.31	0.36
Stddev. Lat. Error	4.39	5.16	6.28	6.73
Max. Lat. Error	55.5	33.84	38.94	33.12
Min. Lat. Error	-34.77	-38.27	-32.29	-33.24
Avg. Abs. Lat. Error	1.84	3.05	3.5	3.8
Stddev. Abs. Lat. Error	3.99	4.16	5.37	5.57
Max. Abs. Lat. Error	55.5	38.27	38.94	33.24
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.02	0.13	0.72	1.34
Stddev. Long. Error	3.46	4.05	4.66	5.87
Max. Long. Error	46.83	59.63	30.58	34.91
Min. Long. Error	-28	-21.22	-29.72	-22.22
Avg. Abs. Long. Error	2.02	2.47	3.28	3.99
Stddev. Abs. Long. Error	2.82	3.21	3.39	4.5
Max. Abs. Long. Error	46.83	59.63	30.58	34.91
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-1.04	-1413.52	125.61	322.53
Stddev. Vert. Error	1404.76	3060.83	2690.82	5126.08
Max. Vert. Error	17000	17800	23878	28990
Min. Vert. Error	-16406.8	-16708	-14510	-11000
Avg. Abs. Vert. Error	391.85	1981.42	1409.53	2698.07
Stddev. Abs. Vert. Error	1348.99	2727.66	2295.45	4369.08
Max. Abs. Vert. Error	17000	17800	23878	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	3.29	4.51	5.66	6.41
Stddev. Slant Range Error	4.53	4.81	5.61	6.42
Max. Slant Range Error	56.87	67.09	44.23	36.75
Min. Slant Range Error	0.01	0.03	0.01	0.13

Figure A.2- 52 Descriptive Statistics for Flight Types at Look Ahead Time of 600 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME		900 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	4878	2454	3452	414
Avg. Horz. Error	4.71	5.57	8.11	9.55
Stddev. Horz. Error	6.37	5.69	7.02	9.42
Max. Horz. Error	62.17	58.36	56.6	75.25
Min. Horz. Error	0.01	0.06	0.04	0.11
Avg. Lat. Error	-0.04	-0.15	2.24	0.67
Stddev. Lat. Error	6.15	5.57	8.15	8.75
Max. Lat. Error	60.84	31.18	54.78	42.67
Min. Lat. Error	-39.76	-38.45	-37.58	-43.96
Avg. Abs. Lat. Error	2.55	3.35	4.92	4.96
Stddev. Abs. Lat. Error	5.6	4.45	6.88	7.24
Max. Abs. Lat. Error	60.84	38.45	54.78	43.96
Min. Abs. Lat. Error	0	0	0	0.01
Avg. Long. Error	0.14	0.18	0.84	2.19
Stddev. Long. Error	5	5.69	6.54	9.91
Max. Long. Error	37.39	58.31	30.21	49.55
Min. Long. Error	-31.86	-25.91	-36.79	-61.99
Avg. Abs. Long. Error	2.96	3.54	4.8	6.72
Stddev. Abs. Long. Error	4.03	4.46	4.53	7.6
Max. Abs. Long. Error	37.39	58.31	36.79	61.99
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-17.72	-1885.93	422.37	618.61
Stddev. Vert. Error	1771.44	3465.79	3085.12	6181.16
Max. Vert. Error	17000	17747	29003	28990
Min. Vert. Error	-20550	-19945.7	-14955.2	-14133
Avg. Abs. Vert. Error	517.43	2473.02	1501.08	3263.83
Stddev. Abs. Vert. Error	1694.26	3074.35	2728.1	5283.17
Max. Abs. Vert. Error	20550	19945.74	29003	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	4.72	5.64	8.14	9.61
Stddev. Slant Range Error	6.37	5.66	7.01	9.42
Max. Slant Range Error	62.17	58.36	56.6	75.4
Min. Slant Range Error	0.01	0.11	0.05	0.23

Figure A.2- 53 Descriptive Statistics for Flight Types at Look Ahead Time of 900 and Samples at Altitudes Above 18,000 Feet

LOOKAHEAD TIME			1200 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	3806	1595	2511	262
Avg. Horz. Error	6.2	6.48	10.45	13.44
Stddev. Horz. Error	8.27	6.48	8.24	13.19
Max. Horz. Error	78.4	63.92	56.61	86.73
Min. Horz. Error	0.03	0.02	0.01	0.39
Avg. Lat. Error	-0.05	-0.05	2.94	-0.15
Stddev. Lat. Error	7.76	5.95	9.55	10.05
Max. Lat. Error	76.1	26.35	53.39	41.78
Min. Lat. Error	-55.56	-38.88	-49.48	-50.89
Avg. Abs. Lat. Error	3.23	3.59	6.14	5.66
Stddev. Abs. Lat. Error	7.06	4.74	7.88	8.3
Max. Abs. Lat. Error	76.1	38.88	53.39	50.89
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.32	0.19	1.31	3.72
Stddev. Long. Error	6.82	6.97	8.68	15.5
Max. Long. Error	38.33	63.92	44.46	77.59
Min. Long. Error	-40.8	-30.92	-35.88	-85.87
Avg. Abs. Long. Error	4.02	4.39	6.48	10.61
Stddev. Abs. Long. Error	5.52	5.42	5.92	11.88
Max. Abs. Long. Error	40.8	63.92	44.46	85.87
Min. Abs. Long. Error	0	0	0	0.04
Avg. Vert. Error	-26.6	-1946.08	507.25	1082.46
Stddev. Vert. Error	1904.24	3537.6	3196.61	6391.57
Max. Vert. Error	17000	15000	29003	28990
Min. Vert. Error	-17851	-19633	-16708	-11108
Avg. Abs. Vert. Error	588.35	2612.74	1481.99	3343.97
Stddev. Abs. Vert. Error	1811.25	3077.91	2877.25	5550.08
Max. Abs. Vert. Error	17851	19633	29003	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	6.22	6.55	10.46	13.48
Stddev. Slant Range Error	8.27	6.44	8.23	13.19
Max. Slant Range Error	78.4	63.95	56.61	86.86
Min. Slant Range Error	0.03	0.09	0.01	0.49

Figure A.2- 54 Descriptive Statistics for Flight Types at Look Ahead Time of 1200 and Samples at Altitudes Above 18,000 Feet

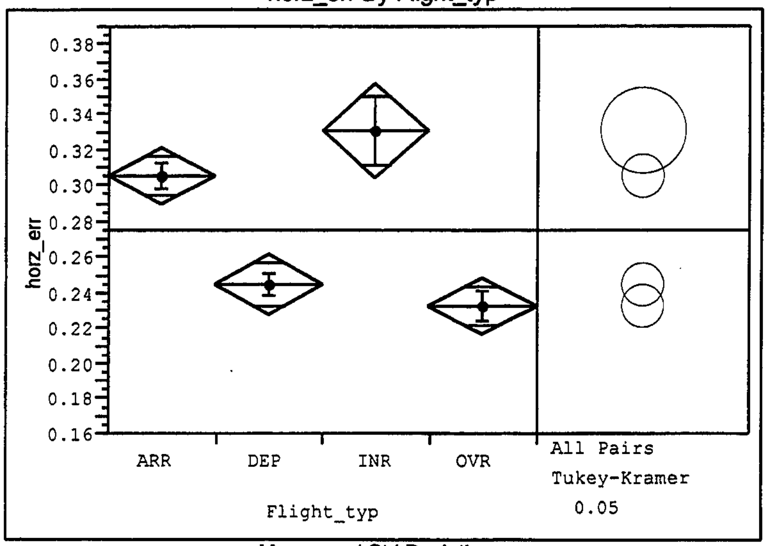
	LOOKAHEAD TIME		1500 Seconds	
Flight type	OVR	ARR	DEP	INR
Sample Quantity	2917	975	1649	155
Avg. Horz. Error	7.69	7.17	12.36	14.49
Stddev. Horz. Error	10.2	6.29	9.55	13.37
Max. Horz. Error	87.22	39.59	85.79	75.25
Min. Horz. Error	0.03	0.13	0.09	0.74
Avg. Lat. Error	-0.1	-0.15	3.1	-2.24
Stddev. Lat. Error	9.43	6.6	10.56	9.81
Max. Lat. Error	85.67	27.93	67.1	42.67
Min. Lat. Error	-65.63	-38.45	-53.87	-58.18
Avg. Abs. Lat. Error	3.92	3.96	6.88	5.47
Stddev. Abs. Lat. Error	8.57	5.28	8.59	8.44
Max. Abs. Lat. Error	85.67	38.45	67.1	58.18
Min. Abs. Lat. Error	0	0	0	0.02
Avg. Long. Error	0.54	0.35	1.33	3.18
Stddev. Long. Error	8.6	6.88	11	16.69
Max. Long. Error	47.19	39.59	61.01	63.91
Min. Long. Error	-49.89	-26.43	-53.47	-61.99
Avg. Abs. Long. Error	5.04	4.83	8.14	11.85
Stddev. Abs. Long. Error	6.98	4.91	7.52	12.15
Max. Abs. Long. Error	49.89	39.59	61.01	63.91
Min. Abs. Long. Error	0	0	0	0.4
Avg. Vert. Error	-91.11	-1991.53	662.11	540.24
Stddev. Vert. Error	2072.35	3683.8	3089.13	5740.7
Max. Vert. Error	17000	10600	29003	28990
Min. Vert. Error	-20550	-19924.8	-13633	-12269.3
Avg. Abs. Vert. Error	674.7	2779.56	1433.13	3219.4
Stddev. Abs. Vert. Error	1961.52	3131.57	2815.36	4776.77
Max. Abs. Vert. Error	20550	19924.8	29003	28990
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	7.7	7.23	12.37	14.53
Stddev. Slant Range Error	10.19	6.26	9.54	13.37
Max. Slant Range Error	87.23	39.59	85.79	75.4
Min. Slant Range Error	0.03	0.22	0.09	0.74

Figure A.2- 55 Descriptive Statistics for Flight Types at Look Ahead Time of 1500 and Samples All Altitudes Above 18,000 Feet

LOOKAHEAD TIME		1800 Seconds		
Flight type	OVR	ARR	DEP	INR
Sample Quantity	2217	568	1051	76
Avg. Horz. Error	9.14	8.36	13.61	15.31
Stddev. Horz. Error	11.83	7.47	10.03	14.12
Max. Horz. Error	87.65	48.09	77.52	70.24
Min. Horz. Error	0.06	0.03	0.03	0.28
Avg. Lat. Error	0.04	-0.5	3.08	-3.64
Stddev. Lat. Error	10.59	8.21	10.43	9.85
Max. Lat. Error	86.54	26.68	38.98	21.05
Min. Lat. Error	-62.21	-45.06	-54.59	-42.31
Avg. Abs. Lat. Error	4.55	4.86	6.85	6.07
Stddev. Abs. Lat. Error	9.57	6.63	8.44	8.55
Max. Abs. Lat. Error	86.54	45.06	54.59	42.31
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.86	0.83	0.88	-0.09
Stddev. Long. Error	10.52	7.58	12.92	18.07
Max. Long. Error	55.83	44.94	77.47	69.78
Min. Long. Error	-58.65	-26.15	-38.24	-38.11
Avg. Abs. Long. Error	6.11	5.44	9.57	12.14
Stddev. Abs. Long. Error	8.6	5.34	8.73	13.31
Max. Abs. Long. Error	58.65	44.94	77.47	69.78
Min. Abs. Long. Error	0	0	0	0.05
Avg. Vert. Error	-118.67	-2134.48	854.48	954.04
Stddev. Vert. Error	2096.6	4030.35	3332.79	5918.06
Max. Vert. Error	17000	10300	29003	24000
Min. Vert. Error	-17851	-16650	-12600	-11111
Avg. Abs. Vert. Error	724.52	3095.99	1601.06	3628.15
Stddev. Abs. Vert. Error	1970.95	3347.49	3045.08	4754.66
Max. Abs. Vert. Error	17851	16650	29003	24000
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	9.15	8.42	13.63	15.34
Stddev. Slant Range Error	11.83	7.44	10.02	14.12
Max. Slant Range Error	87.65	48.12	77.67	70.29
Min. Slant Range Error	0.06	0.24	0.03	0.28

Figure A.2- 56 Descriptive Statistics for Flight Types at Look Ahead Time of 1800 and Samples at Altitudes Above 18,000 Feet

A.2.2.2 Statistical Tests



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	9698	0.310898	0.80951	0.00822
DEP	9424	0.252214	0.60633	0.00625
INR	3626	0.334457	1.23489	0.02051
OVR	9811	0.240831	0.90871	0.00917

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.000000	0.023559	0.082243	0.093626
ARR	-0.02356	0.000000	0.058684	0.070067
DEP	-0.08224	-0.05868	0.000000	0.011383
OVR	-0.09363	-0.07007	-0.01138	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56916

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-0.05121	-0.01888	0.039634	0.051251
ARR	-0.01888	-0.03131	0.027145	0.038845
DEP	0.039634	0.027145	-0.03176	-0.02007
OVR	0.051251	0.038845	-0.02007	-0.03113

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

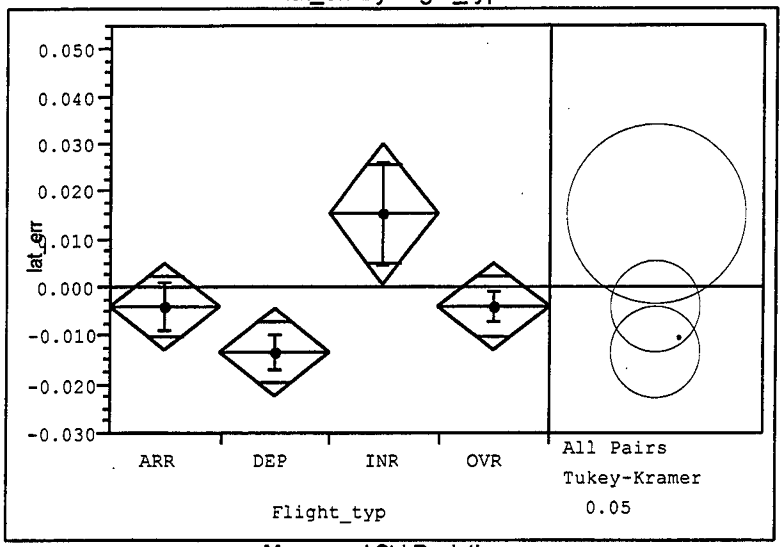
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	9698	0.809514	0.2831427	0.2338476
DEP	9424	0.606328	0.2143921	0.1806981
INR	3626	1.234889	0.3370098	0.2656528
OVR	9811	0.908712	0.2119356	0.1740642

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.7896	3	32555	0.0099
Brown-Forsythe	17.3523	3	32555	<.0001
Levene	32.5325	3	32555	<.0001
Bartlett	1064.1399	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
17.6030	3	12510	<.0001

Figure A.2- 57 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	9698	-0.00095	0.519224	0.00527
DEP	9424	-0.01009	0.387463	0.00399
INR	3626	0.018935	0.648047	0.01076
OVR	9811	0.004879	0.344793	0.00348

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	OVR	ARR	DEP
INR	0.000000	0.014056	0.019886	0.029028
OVR	-0.01406	0.000000	0.005830	0.014972
ARR	-0.01989	-0.00583	0.000000	0.009142
DEP	-0.02903	-0.01497	-0.00914	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56916

Abs(Dif)-LSD	INR	OVR	ARR	DEP
INR	-0.02741	-0.00863	-0.00283	0.006221
OVR	-0.00863	-0.01666	-0.01088	-0.00186
ARR	-0.00283	-0.01088	-0.01676	-0.00774
DEP	0.006221	-0.00186	-0.00774	-0.017

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

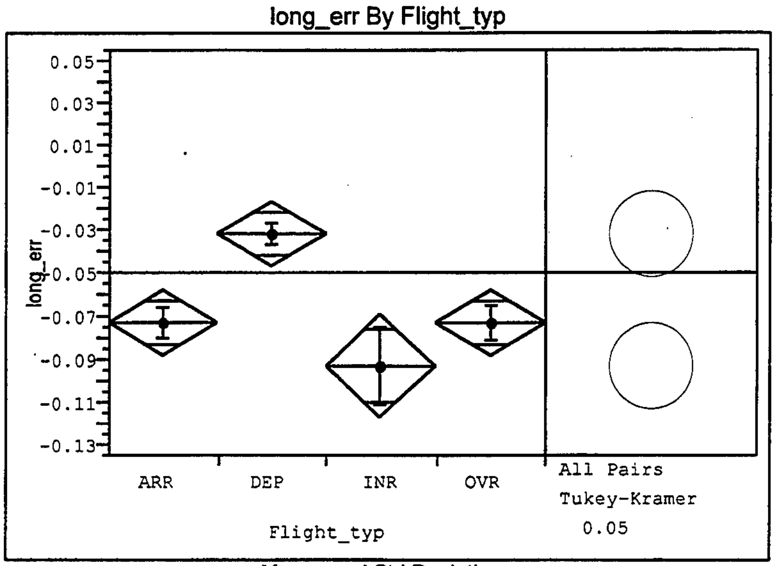
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	9698	0.5192241	0.1598022	0.1598021
DEP	9424	0.3874632	0.1150324	0.1139145
INR	3626	0.6480467	0.1747049	0.1703137
OVR	9811	0.3447934	0.0888259	0.0884648

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.4078	3	32555	0.0042
Brown-Forsythe	58.7598	3	32555	<.0001
Levene	60.5115	3	32555	<.0001
Bartlett	1079.1302	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.8104	3	12523	0.0096

Figure A.2- 58 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	9698	-0.05228	0.69257	0.00703
DEP	9424	-0.02979	0.52928	0.00545
INR	3626	-0.0791	1.10012	0.01827
OVR	9811	-0.05522	0.87282	0.00881

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.000000	0.022487	0.025426	0.049301
ARR	-0.02249	0.000000	0.002939	0.026814
OVR	-0.02543	-0.00294	0.000000	0.023875
INR	-0.0493	-0.02681	-0.02388	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56916

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-0.02871	-0.00602	-0.003	0.010793
ARR	-0.00602	-0.0283	-0.02528	-0.01154
OVR	-0.003	-0.02528	-0.02813	-0.01442
INR	0.010793	-0.01154	-0.01442	-0.04628

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	9698	0.692568	0.2154040	0.2153890
DEP	9424	0.529277	0.1871705	0.1865599
INR	3626	1.100120	0.2469661	0.2427026
OVR	9811	0.872815	0.1980230	0.1969770

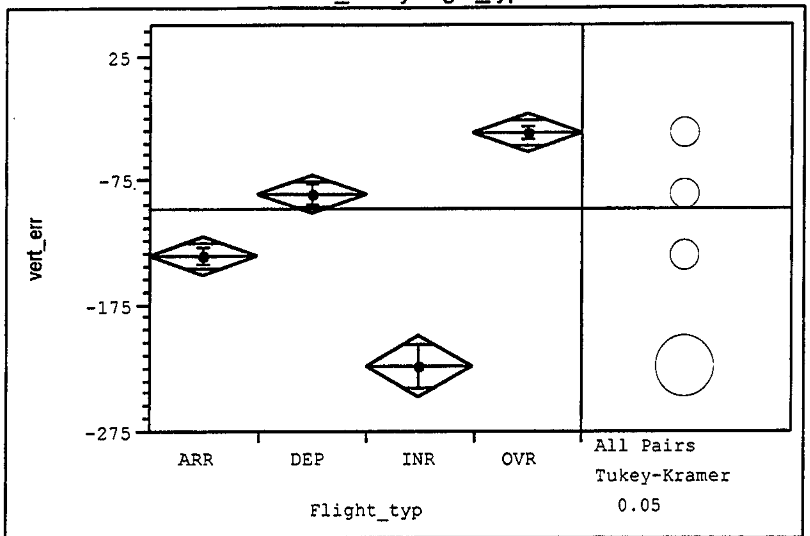
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.3723	3	32555	0.0176
Brown-Forsythe	6.1180	3	32555	0.0004
Levene	6.6584	3	32555	0.0002
Bartlett	1273.2348	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
4.4776	3	12473	0.0038

Figure A.2- 59 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 0 for Samples at All Altitudes

vert_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	9698	-136.853	767.97	7.798
DEP	9424	-86.469	839.17	8.644
INR	3626	-223.639	1035.82	17.202
OVR	9811	-26.653	628.20	6.342

Means Comparisons

Dif=Mean[i]-Mean[j]	OVR	DEP	ARR	INR
OVR	0.000	59.817	110.200	196.987
DEP	-59.817	0.000	50.383	137.170
ARR	-110.200	-50.383	0.000	86.787
INR	-196.987	-137.170	-86.787	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56916

Abs(Dif)-LSD	OVR	DEP	ARR	INR
OVR	-28.834	30.688	81.282	157.738
DEP	30.688	-29.420	21.171	97.704
ARR	81.282	21.171	-29.002	47.476
INR	157.738	97.704	47.476	-47.430

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

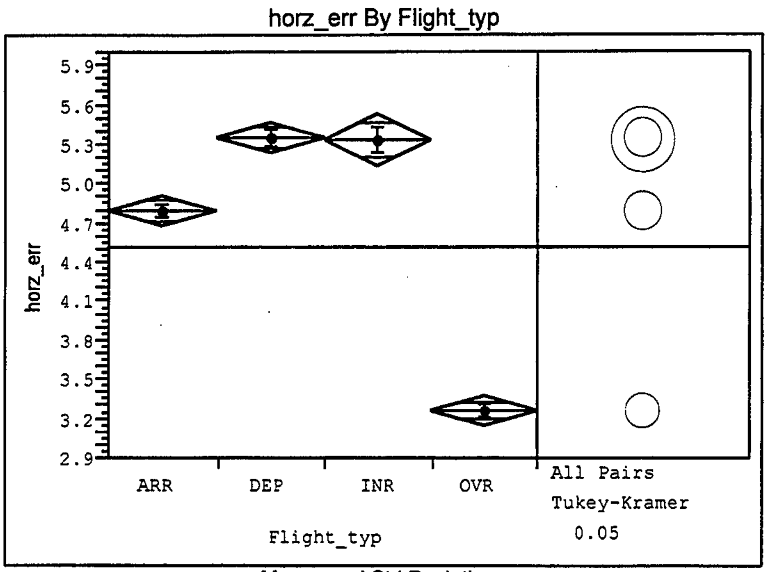
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	9698	767.970	249.2032	187.8927
DEP	9424	839.169	185.1839	147.8805
INR	3626	1035.819	405.3568	319.9138
OVR	9811	628.197	85.1985	64.7526

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.6194	3	32555	0.0491
Brown-Forsythe	104.9176	3	32555	<.0001
Levene	180.2678	3	32555	<.0001
Bartlett	539.1360	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
64.5361	3	12695	<.0001

Figure A.2- 60 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	6410	4.81263	4.72863	0.05906
DEP	6127	5.35402	5.48387	0.07006
INR	2378	5.33299	4.88957	0.10027
OVR	6964	3.26441	4.40919	0.05284

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	ARR	OVR
DEP	0.00000	0.02103	0.54139	2.08961
INR	-0.02103	0.00000	0.52036	2.06858
ARR	-0.54139	-0.52036	0.00000	1.54822
OVR	-2.08961	-2.06858	-1.54822	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56923

Abs(Dif)-LSD	DEP	INR	ARR	OVR
DEP	-0.22626	-0.28154	0.31765	1.87026
INR	-0.28154	-0.36318	0.21967	1.77114
ARR	0.31765	0.21967	-0.22121	1.33145
OVR	1.87026	1.77114	1.33145	-0.21223

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

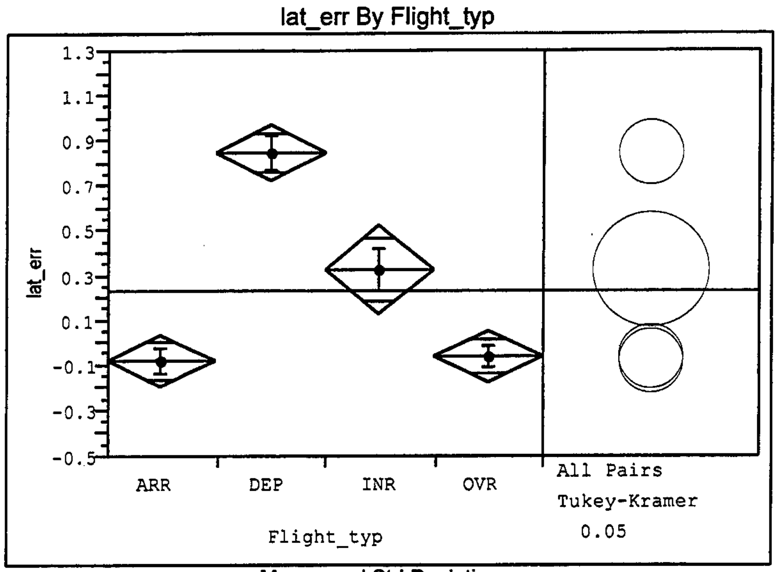
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	6410	4.728632	3.305763	3.089800
DEP	6127	5.483868	3.923596	3.670080
INR	2378	4.889567	3.525267	3.368692
OVR	6964	4.409194	2.758096	2.388764

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	14.9169	3	21875	<.0001
Brown-Forsythe	114.0037	3	21875	<.0001
Levene	121.0969	3	21875	<.0001
Bartlett	109.0100	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
260.8810	3	8784.1	<.0001

Figure A.2- 61 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	6410	-0.07385	4.88907	0.06107
DEP	6127	0.855664	5.95637	0.07610
INR	2378	0.333792	4.82253	0.09889
OVR	6964	-0.05715	4.22934	0.05068

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.000000	0.521872	0.912819	0.929514
INR	-0.52187	0.000000	0.390947	0.407642
OVR	-0.91282	-0.39095	0.000000	0.016695
ARR	-0.92951	-0.40764	-0.0167	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56923

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-0.23283	0.210513	0.687090	0.699265
INR	0.210513	-0.37373	0.084864	0.098211
OVR	0.687090	0.084864	-0.21839	-0.20637
ARR	0.699265	0.098211	-0.20637	-0.22764

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

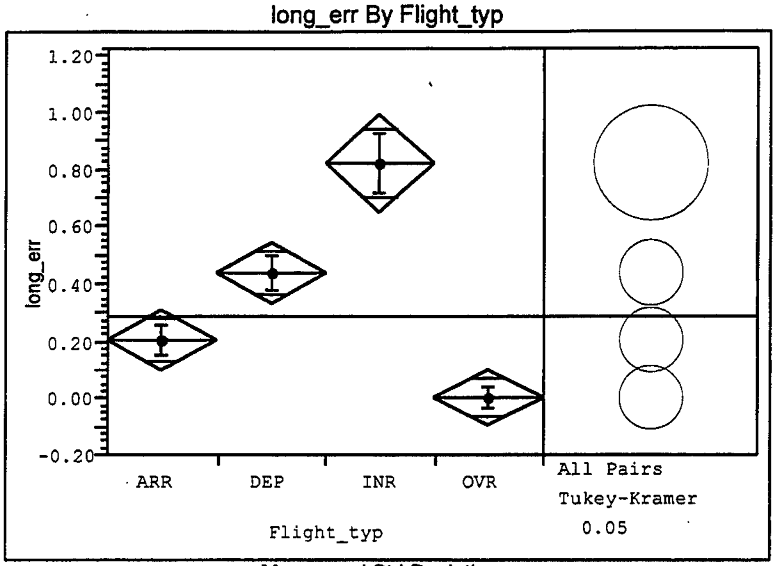
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	6410	4.889072	2.926194	2.925056
DEP	6127	5.956371	3.489681	3.283112
INR	2378	4.822525	2.801543	2.776986
OVR	6964	4.229340	1.815585	1.814337

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	42.1508	3	21875	<.0001
Brown-Forsythe	145.6878	3	21875	<.0001
Levene	184.8489	3	21875	<.0001
Bartlett	261.7352	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
39.8590	3	8775.4	<.0001

Figure A.2- 62 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	6410	0.233064	4.64351	0.05800
DEP	6127	0.462771	4.72422	0.06035
INR	2378	0.821925	5.32133	0.10912
OVR	6964	0.021720	3.49397	0.04187

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.000000	0.359155	0.588861	0.800205
DEP	-0.35915	0.000000	0.229706	0.441050
ARR	-0.58886	-0.22971	0.000000	0.211344
OVR	-0.80021	-0.44105	-0.21134	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56923

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-0.32928	0.084830	0.316235	0.530529
DEP	0.084830	-0.20514	0.026844	0.242171
ARR	0.316235	0.026844	-0.20056	0.014814
OVR	0.530529	0.242171	0.014814	-0.19242

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

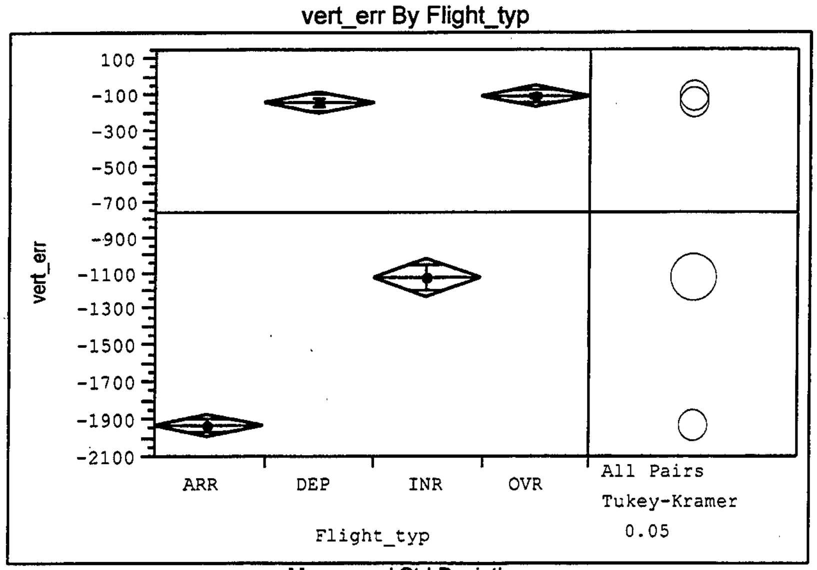
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	6410	4.643507	3.004258	3.001655
DEP	6127	4.724217	3.200885	3.188288
INR	2378	5.321330	3.635635	3.623661
OVR	6964	3.493972	2.043733	2.043354

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	39.2139	3	21875	<.0001
Brown-Forsythe	199.5752	3	21875	<.0001
Levene	204.0091	3	21875	<.0001
Bartlett	312.3250	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
23.0074	3	8417.5	<.0001

Figure A.2- 63 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	6410	-1923.41	3217.90	40.192
DEP	6127	-140.57	2691.21	34.381
INR	2378	-1127.88	3808.73	78.104
OVR	6964	-106.29	1577.38	18.902

Means Comparisons

Dif=Mean[i]-Mean[j]	OVR	DEP	INR	ARR
OVR	0.00	34.29	1021.59	1817.13
DEP	-34.29	0.00	987.31	1782.84
INR	-1021.59	-987.31	0.00	795.53
ARR	-1817.13	-1782.84	-795.53	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56923

Abs(Dif)-LSD	OVR	DEP	INR	ARR
OVR	-118.68	-88.38	855.26	1695.90
DEP	-88.38	-126.53	818.10	1657.71
INR	855.26	818.10	-203.10	627.37
ARR	1695.90	1657.71	627.37	-123.71

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

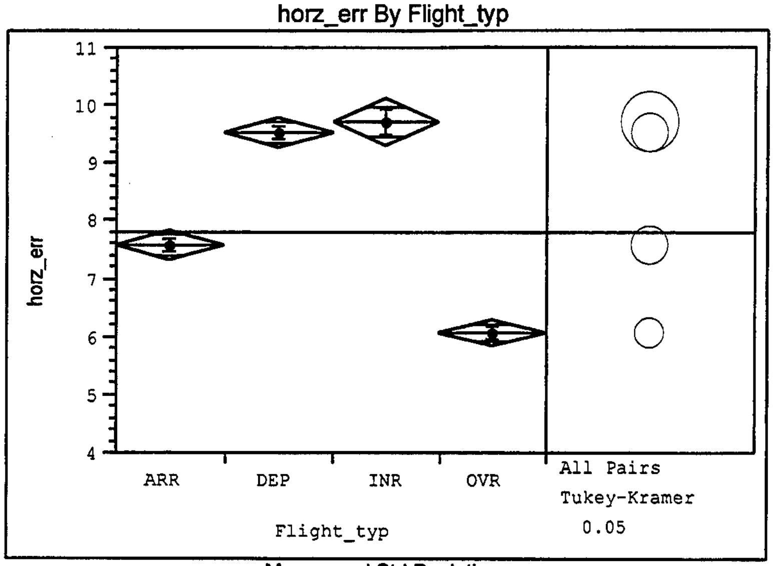
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	6410	3217.898	2405.257	2306.734
DEP	6127	2691.211	1453.928	1395.545
INR	2378	3808.727	2535.934	2398.314
OVR	6964	1577.378	556.658	476.562

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	168.1225	3	21875	<.0001
Brown-Forsythe	886.3388	3	21875	0.0000
Levene	1068.1096	3	21875	0.0000
Bartlett	1352.3183	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
607.1591	3	7913.5	0.0000

Figure A.2- 64 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3585	7.57846	7.04364	0.11764
DEP	3426	9.57077	8.45039	0.14437
INR	1411	9.71904	9.14956	0.24358
OVR	4484	6.08676	7.91783	0.11824

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.00000	0.14828	2.14058	3.63229
DEP	-0.14828	0.00000	1.99231	3.48401
ARR	-2.14058	-1.99231	0.00000	1.49171
OVR	-3.63229	-3.48401	-1.49171	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56937

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-0.77187	-0.50025	1.49627	3.00648
DEP	-0.50025	-0.49535	1.50247	3.01879
ARR	1.49627	1.50247	-0.48424	1.03237
OVR	3.00648	3.01879	1.03237	-0.43299

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

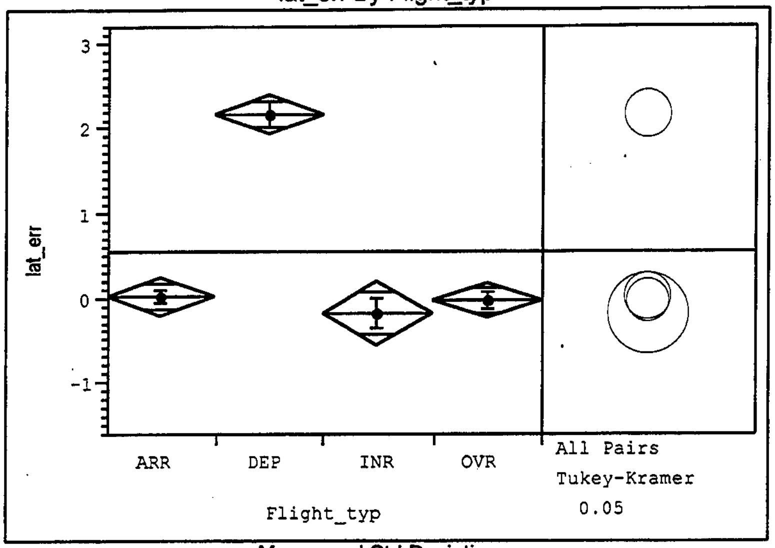
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3585	7.043636	5.184324	4.855789
DEP	3426	8.450394	6.336549	6.114365
INR	1411	9.149565	6.393235	6.153383
OVR	4484	7.917826	5.075809	4.439521

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	9.1732	3	12902	<.0001
Brown-Forsythe	56.5756	3	12902	<.0001
Levene	47.6911	3	12902	<.0001
Bartlett	61.5680	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
141.2398	3	5061.2	<.0001

Figure A.2- 65 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3585	0.01866	5.92363	0.09893
DEP	3426	2.18014	8.90710	0.15217
INR	1411	-0.15311	6.78403	0.18060
OVR	4484	-0.01506	7.37213	0.11009

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.00000	2.16148	2.19520	2.33325
ARR	-2.16148	0.00000	0.03372	0.17177
OVR	-2.19520	-0.03372	0.00000	0.13804
INR	-2.33325	-0.17177	-0.13804	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56937

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-0.45923	1.70737	1.76391	1.73202
ARR	1.70737	-0.44893	-0.39211	-0.42556
OVR	1.76391	-0.39211	-0.40141	-0.44212
INR	1.73202	-0.42556	-0.44212	-0.71558

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3585	5.923634	3.528745	3.527918
DEP	3426	8.907101	5.855866	5.388564
INR	1411	6.784031	3.895724	3.882217
OVR	4484	7.372126	3.109415	3.108946

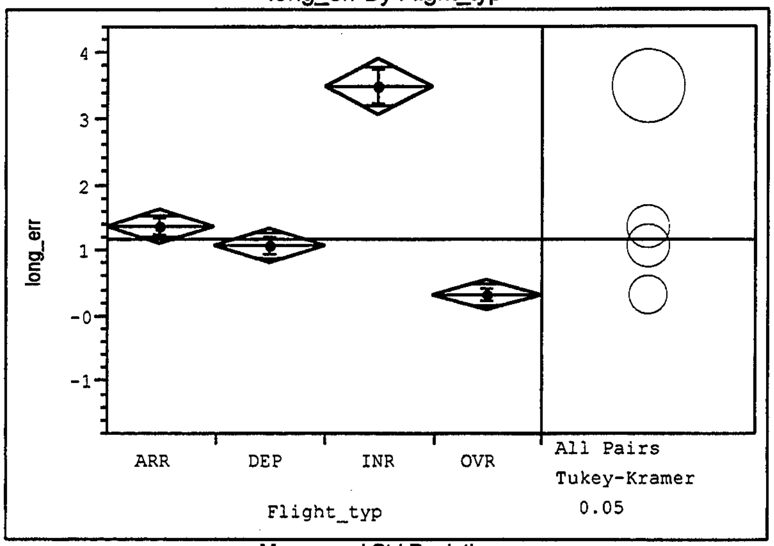
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	27.2043	3	12902	<.0001
Brown-Forsythe	91.5585	3	12902	<.0001
Levene	144.9279	3	12902	<.0001
Bartlett	198.3974	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
58.1885	3	5213.7	<.0001

Figure A.2- 66 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 1200 for Samples at All Altitudes

long_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3585	1.38903	8.3691	0.13978
DEP	3426	1.12294	8.8138	0.15058
INR	1411	3.54592	10.9367	0.29116
OVR	4484	0:36605	6.7280	0.10047

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.00000	2.15689	2.42298	3.17987
ARR	-2.15689	0.00000	0.26609	1.02298
DEP	-2.42298	-0.26609	0.00000	0.75689
OVR	-3.17987	-1.02298	-0.75689	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56937

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-0.80283	1.48674	1.74845	2.52897
ARR	1.48674	-0.50366	-0.24338	0.54523
DEP	1.74845	-0.24338	-0.51522	0.27301
OVR	2.52897	0.54523	0.27301	-0.45035

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

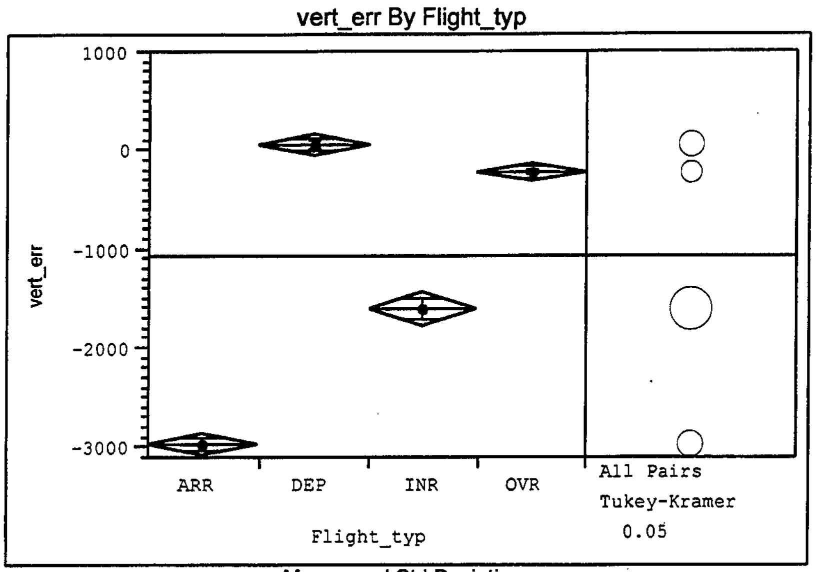
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3585	8.36912	5.518321	5.514633
DEP	3426	8.81381	6.217601	6.192209
INR	1411	10.93674	7.593686	7.471313
OVR	4484	6.72803	4.027240	4.026134

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	40.8904	3	12902	<.0001
Brown-Forsythe	143.3800	3	12902	<.0001
Levene	153.3512	3	12902	<.0001
Bartlett	210.5479	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
41.4609	3	4860.8	<.0001

Figure A.2- 67 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3585	-2970.29	4031.85	67.34
DEP	3426	68.13	3271.64	55.89
INR	1411	-1597.06	4499.37	119.78
OVR	4484	-209.47	2166.89	32.36

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	INR	ARR
DEP	0.00	277.60	1665.19	3038.43
OVR	-277.60	0.00	1387.59	2760.83
INR	-1665.19	-1387.59	0.00	1373.23
ARR	-3038.43	-2760.83	-1373.23	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56937

Abs(Dif)-LSD	DEP	OVR	INR	ARR
DEP	-207.77	82.48	1393.18	2832.98
OVR	82.48	-181.61	1125.11	2568.17
INR	1393.18	1125.11	-323.75	1102.99
ARR	2832.98	2568.17	1102.99	-203.11

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3585	4031.854	3023.812	2970.805
DEP	3426	3271.645	1573.212	1542.725
INR	1411	4499.375	3116.725	2998.359
OVR	4484	2166.889	868.074	711.378

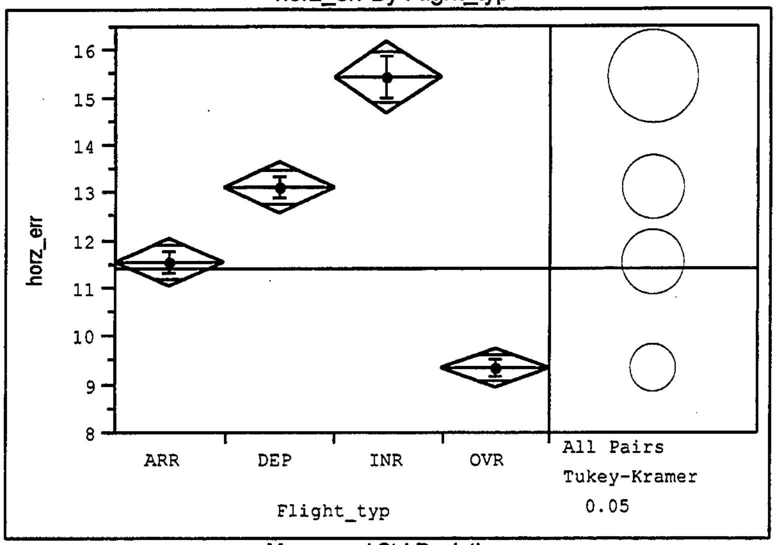
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	87.0695	3	12902	<.0001
Brown-Forsythe	564.8393	3	12902	0.0000
Levene	586.7886	3	12902	0.0000
Bartlett	627.8118	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
532.1272	3	4663.8	<.0001

Figure A.2- 68 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 1200 for Samples at All Altitudes

horz_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1634	11.0198	10.4753	0.25914
DEP	1567	12.6005	10.4800	0.26474
INR	737	14.9629	12.9118	0.47561
OVR	2714	8.8507	11.1183	0.21342

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.00000	2.36246	3.94317	6.11220
DEP	-2.36246	0.00000	1.58071	3.74974
ARR	-3.94317	-1.58071	0.00000	2.16903
OVR	-6.11220	-3.74974	-2.16903	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56968

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-1.47693	1.09612	2.68516	4.93456
DEP	1.09612	-1.01288	0.57826	2.85022
ARR	2.68516	0.57826	-0.99190	1.28128
OVR	4.93456	2.85022	1.28128	-0.76964

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1634	10.47529	7.977267	7.289042
DEP	1567	10.47996	8.039309	7.820326
INR	737	12.91176	9.922220	9.620093
OVR	2714	11.11833	7.250634	6.396928

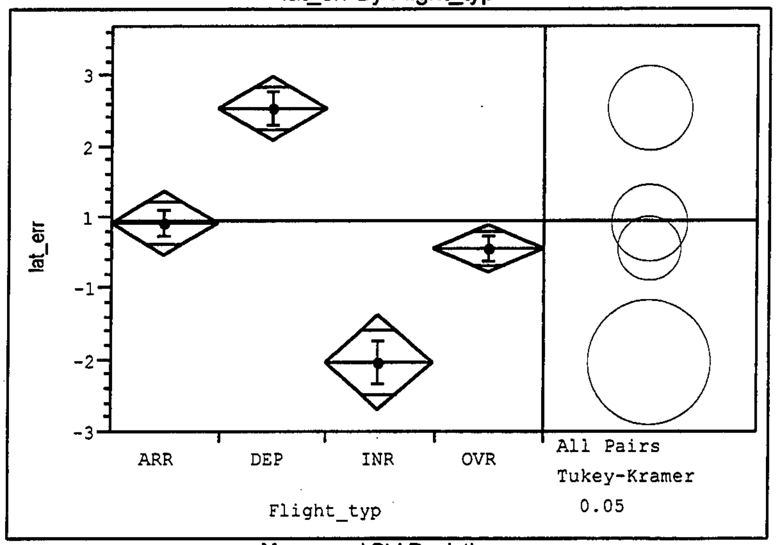
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.7179	3	6648	0.0027
Brown-Forsythe	27.5631	3	6648	<.0001
Levene	23.9272	3	6648	<.0001
Bartlett	19.1123	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
68.8395	3	2542.8	<.0001

Figure A.2- 69 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 1800 for Samples at All Altitudes

lat_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1634	0.46028	8.0212	0.19843
DEP	1567	2.07270	10.0917	0.25493
INR	737	-1.50990	8.3800	0.30868
OVR	2714	0.05156	9.8547	0.18916

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.00000	1.61242	2.02115	3.58260
ARR	-1.61242	0.00000	0.40873	1.97018
OVR	-2.02115	-0.40873	0.00000	1.56145
INR	-3.58260	-1.97018	-1.56145	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56968

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-0.85727	0.76398	1.25982	2.51080
ARR	0.76398	-0.83951	-0.34264	0.90543
OVR	1.25982	-0.34264	-0.65140	0.56473
INR	2.51080	0.90543	0.56473	-1.25003

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

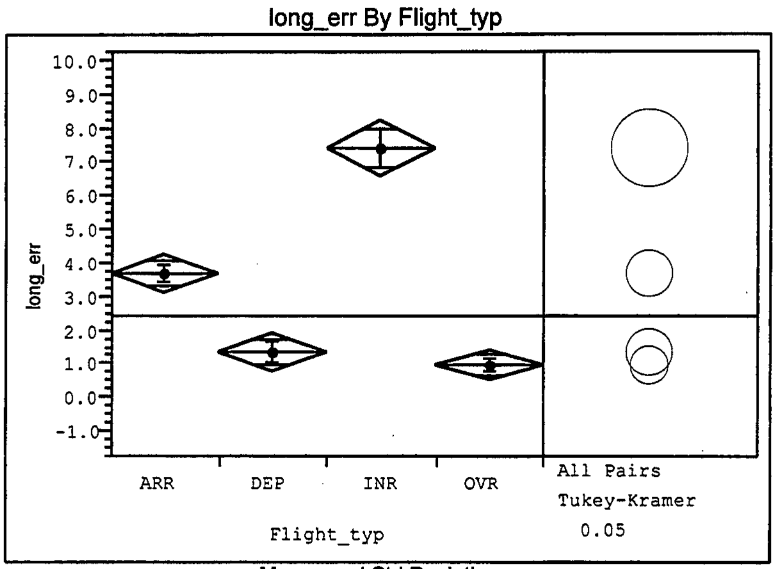
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1634	8.02125	4.673304	4.643139
DEP	1567	10.09165	6.382374	6.034568
INR	737	8.38002	5.275666	5.083819
OVR	2714	9.85469	4.269839	4.258889

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.3364	3	6648	0.0046
Brown-Forsythe	16.9347	3	6648	<.0001
Levene	25.2209	3	6648	<.0001
Bartlett	40.1958	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
28.2321	3	2667.7	<.0001

Figure A.2- 70 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1634	3.68306	12.3740	0.30611
DEP	1567	1.35263	12.6780	0.32027
INR	737	7.40436	16.2327	0.59794
OVR	2714	0.95296	10.1959	0.19571

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	ARR	DEP	OVR
INR	0.00000	3.72130	6.05174	6.45140
ARR	-3.72130	0.00000	2.33044	2.73010
DEP	-6.05174	-2.33044	0.00000	0.39967
OVR	-6.45140	-2.73010	-0.39967	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56968

Abs(Dif)-LSD	INR	ARR	DEP	OVR
INR	-1.62338	2.33854	4.65982	5.15699
ARR	2.33854	-1.09026	1.22859	1.75432
DEP	4.65982	1.22859	-1.11332	-0.58905
OVR	5.15699	1.75432	-0.58905	-0.84596

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1634	12.37400	8.40865	8.26095
DEP	1567	12.67801	9.24024	9.15995
INR	737	16.23271	12.44291	12.07318
OVR	2714	10.19586	6.07744	6.06200

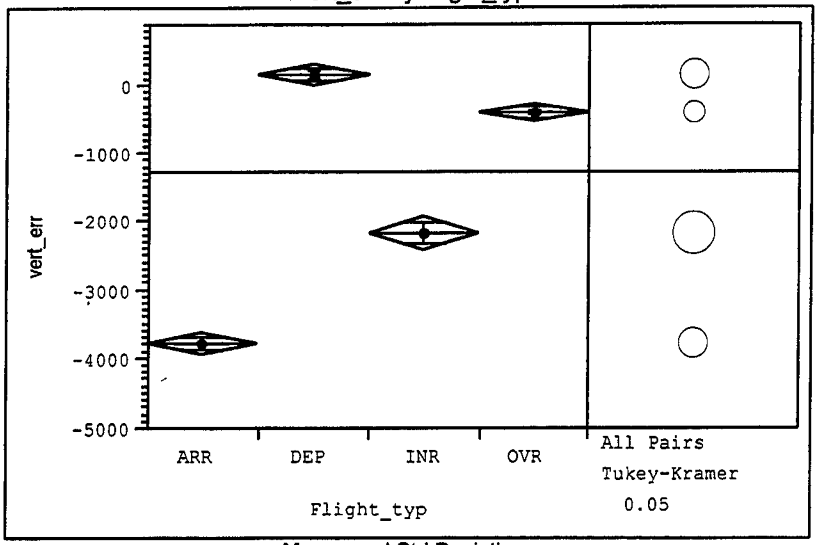
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	33.7000	3	6648	<.0001
Brown-Forsythe	100.4553	3	6648	<.0001
Levene	117.2402	3	6648	<.0001
Bartlett	102.3378	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
48.1804	3	2406.4	<.0001

Figure A.2- 71 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 1800 for Samples at All Altitudes

vert_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1634	-3766.65	4706.02	116.42
DEP	1567	189.57	3381.19	85.42
INR	737	-2143.80	4302.90	158.50
OVR	2714	-366.26	2399.37	46.06

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	INR	ARR
DEP	0.00	555.83	2333.37	3956.22
OVR	-555.83	0.00	1777.53	3400.39
INR	-2333.37	-1777.53	0.00	1622.86
ARR	-3956.22	-3400.39	-1622.86	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56968

Abs(Dif)-LSD	DEP	OVR	INR	ARR
DEP	-324.99	267.21	1927.05	3634.58
OVR	267.21	-246.95	1399.68	3115.54
INR	1927.05	1399.68	-473.89	1219.21
ARR	3634.58	3115.54	1219.21	-318.26

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

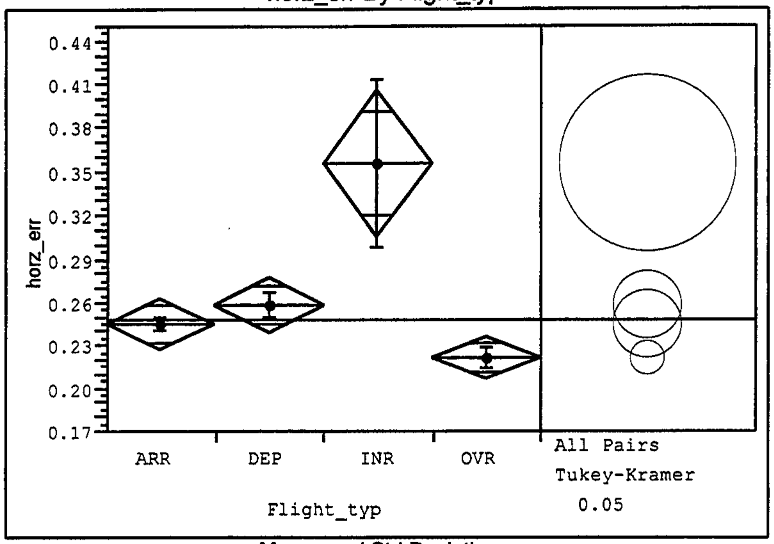
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1634	4706.017	3575.081	3503.073
DEP	1567	3381.185	1742.939	1655.000
INR	737	4302.898	3332.569	3279.080
OVR	2714	2399.368	1148.947	888.459

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	70.8944	3	6648	<.0001
Brown-Forsythe	362.5704	3	6648	<.0001
Levene	353.6240	3	6648	<.0001
Bartlett	345.6304	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
312.4145	3	2303.9	<.0001

Figure A.2- 72 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5944	0.249427	0.43739	0.00567
DEP	5764	0.259489	0.68793	0.00906
INR	835	0.363337	1.68238	0.05822
OVR	8622	0.230576	0.81969	0.00883

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.000000	0.103849	0.113911	0.132762
DEP	-0.10385	0.000000	0.010062	0.028913
ARR	-0.11391	-0.01006	0.000000	0.018851
OVR	-0.13276	-0.02891	-0.01885	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56924

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-0.09476	0.032156	0.042356	0.062589
DEP	0.032156	-0.03607	-0.02573	-0.00403
ARR	0.042356	-0.02573	-0.03552	-0.01379
OVR	0.062589	-0.00403	-0.01379	-0.02949

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

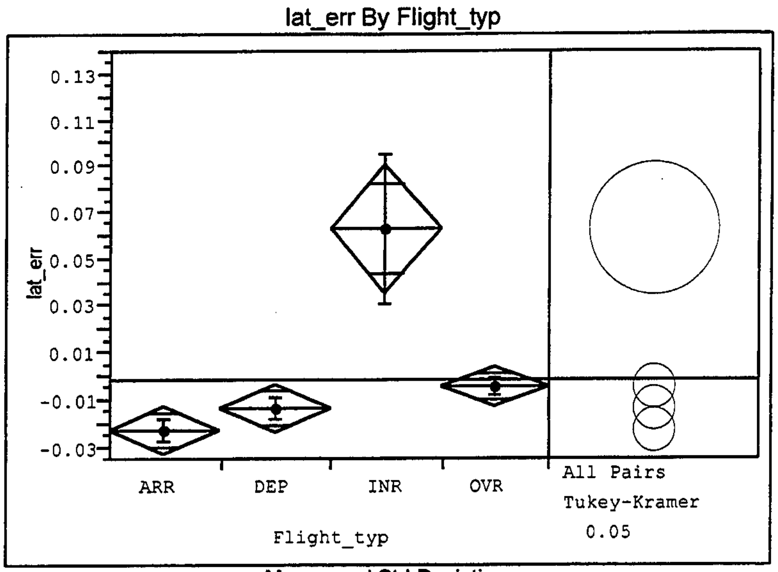
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5944	0.437388	0.1974596	0.1709650
DEP	5764	0.687929	0.2286337	0.1871776
INR	835	1.682376	0.3835806	0.2871825
OVR	8622	0.819693	0.1917282	0.1610402

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.3325	3	21161	0.0047
Brown-Forsythe	7.9475	3	21161	<.0001
Levene	19.7693	3	21161	<.0001
Bartlett	1575.5952	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.1625	3	3581	0.0236

Figure A.2- 73 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5944	-0.01575	0.380916	0.00494
DEP	5764	-0.00519	0.396285	0.00522
INR	835	0.070869	0.942112	0.03260
OVR	8622	0.004471	0.352300	0.00379

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	OVR	DEP	ARR
INR	0.000000	0.066398	0.076054	0.086623
OVR	-0.0664	0.000000	0.009656	0.020225
DEP	-0.07605	-0.00966	0.000000	0.010569
ARR	-0.08662	-0.02022	-0.01057	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56924

Abs(Dif)-LSD	INR	OVR	DEP	ARR
INR	-0.0517	0.028110	0.036937	0.047581
OVR	0.028110	-0.01609	-0.00832	0.002415
DEP	0.036937	-0.00832	-0.01968	-0.00896
ARR	0.047581	0.002415	-0.00896	-0.01938

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5944	0.3809155	0.1353706	0.1336314
DEP	5764	0.3962852	0.1079425	0.1074727
INR	835	0.9421121	0.2163070	0.1859559
OVR	8622	0.3523004	0.0859581	0.0856526

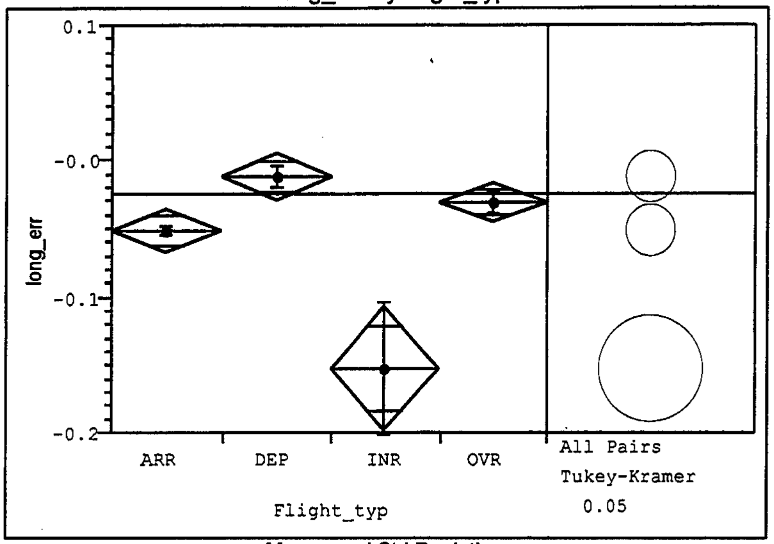
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.2767	3	21161	0.0003
Brown-Forsythe	28.1942	3	21161	<.0001
Levene	39.0256	3	21161	<.0001
Bartlett	871.5923	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
5.2806	3	3564.4	0.0012

Figure A.2- 74 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

long_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5944	-0.06046	0.32331	0.00419
DEP	5764	-0.01901	0.61900	0.00815
INR	835	-0.16516	1.42921	0.04946
OVR	8622	-0.03915	0.77421	0.00834

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	ARR	INR
DEP	0.000000	0.020141	0.041445	0.146146
OVR	-0.02014	0.000000	0.021304	0.126005
ARR	-0.04145	-0.0213	0.000000	0.104701
INR	-0.14615	-0.12601	-0.1047	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56924

Abs(Dif)-LSD	DEP	OVR	ARR	INR
DEP	-0.0324	-0.00945	0.009289	0.081735
OVR	-0.00945	-0.02649	-0.00802	0.062959
ARR	0.009289	-0.00802	-0.03191	0.040413
INR	0.081735	0.062959	0.040413	-0.08513

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5944	0.323314	0.1660477	0.1660012
DEP	5764	0.619000	0.2004258	0.1987010
INR	835	1.429214	0.2944851	0.2584907
OVR	8622	0.774209	0.1874689	0.1874689

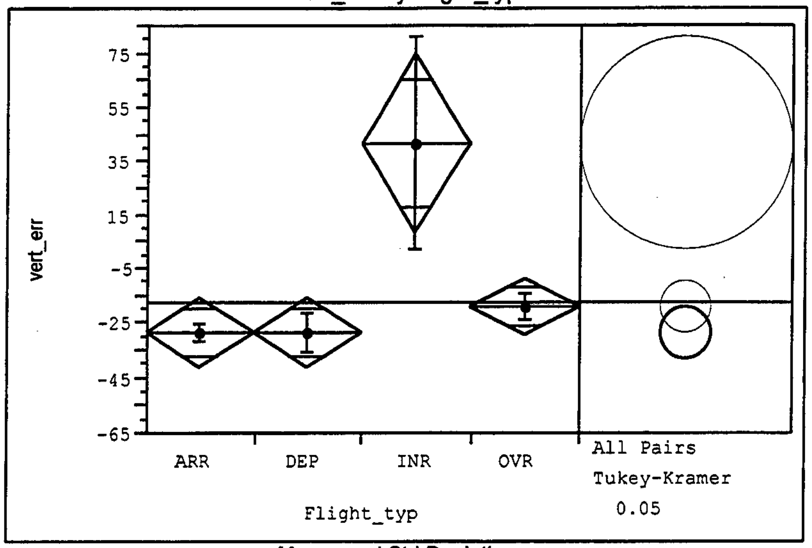
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.0122	3	21161	0.0288
Brown-Forsythe	6.0415	3	21161	0.0004
Levene	10.4225	3	21161	<.0001
Bartlett	2086.4954	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
9.2540	3	3553.9	<.0001

Figure A.2- 75 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

vert_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	5944	-28.3424	251.04	3.256
DEP	5764	-27.1060	560.78	7.386
INR	835	42.8403	1163.20	40.254
OVR	8622	-9.5214	478.37	5.152

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	OVR	DEP	ARR
INR	0.0000	52.3618	69.9463	71.1827
OVR	-52.3618	0.0000	17.5846	18.8210
DEP	-69.9463	-17.5846	0.0000	1.2364
ARR	-71.1827	-18.8210	-1.2364	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56924

Abs(Dif)-LSD	INR	OVR	DEP	ARR
INR	-62.8573	5.8124	22.3889	23.7165
OVR	5.8124	-19.5612	-4.2673	-2.8317
DEP	22.3889	-4.2673	-23.9242	-22.5060
ARR	23.7165	-2.8317	-22.5060	-23.5592

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

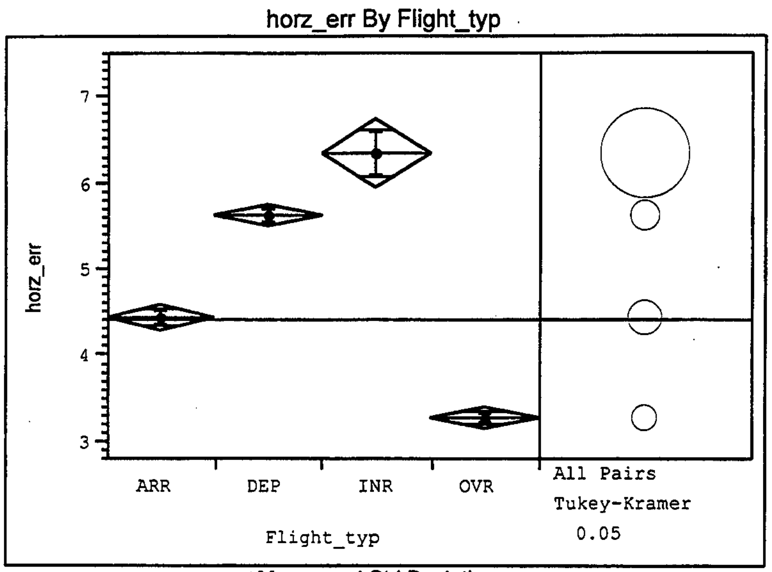
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	5944	251.036	91.8604	76.8985
DEP	5764	560.777	109.4045	94.6887
INR	835	1163.204	202.7138	174.8613
OVR	8622	478.370	52.4152	44.6426

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	9.5397	3	21161	<.0001
Brown-Forsythe	25.0949	3	21161	<.0001
Levene	33.7265	3	21161	<.0001
Bartlett	2070.5746	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
4.1701	3	3540.6	0.0059

Figure A.2- 76 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3524	4.44700	4.82992	0.08136
DEP	4601	5.63019	5.62203	0.08288
INR	587	6.35718	6.42001	0.26498
OVR	6069	3.28254	4.53168	0.05817

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.00000	0.72699	1.91018	3.07464
DEP	-0.72699	0.00000	1.18319	2.34765
ARR	-1.91018	-1.18319	0.00000	1.16446
OVR	-3.07464	-2.34765	-1.16446	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56932

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-0.75686	0.15870	1.33214	2.51418
DEP	0.15870	-0.27034	0.89293	2.09419
ARR	1.33214	0.89293	-0.30890	0.88985
OVR	2.51418	2.09419	0.88985	-0.23538

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3524	4.829923	3.172503	2.900904
DEP	4601	5.622026	4.056605	3.814293
INR	587	6.420010	4.724777	4.247451
OVR	6069	4.531681	2.816014	2.423076

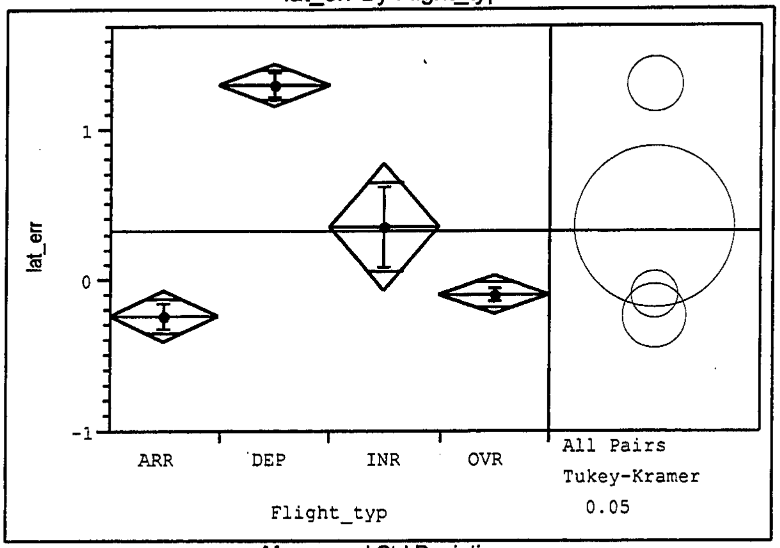
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	16.4402	3	14777	<.0001
Brown-Forsythe	108.2161	3	14777	<.0001
Levene	126.7033	3	14777	<.0001
Bartlett	113.2546	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
207.2099	3	2556	<.0001

Figure A.2- 77 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

lat_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3524	-0.23310	5.15791	0.08689
DEP	4601	1.30717	6.27613	0.09253
INR	587	0.35759	6.73425	0.27795
OVR	6069	-0.09036	4.39379	0.05640

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	INR	OVR	ARR
DEP	0.00000	0.94957	1.39753	1.54027
INR	-0.94957	0.00000	0.44795	0.59069
OVR	-1.39753	-0.44795	0.00000	0.14274
ARR	-1.54027	-0.59069	-0.14274	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56932

Abs(Dif)-LSD	DEP	INR	OVR	ARR
DEP	-0.28512	0.35020	1.13020	1.23413
INR	0.35020	-0.79825	-0.14317	-0.01896
OVR	1.13020	-0.14317	-0.24826	-0.14689
ARR	1.23413	-0.01896	-0.14689	-0.32579

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

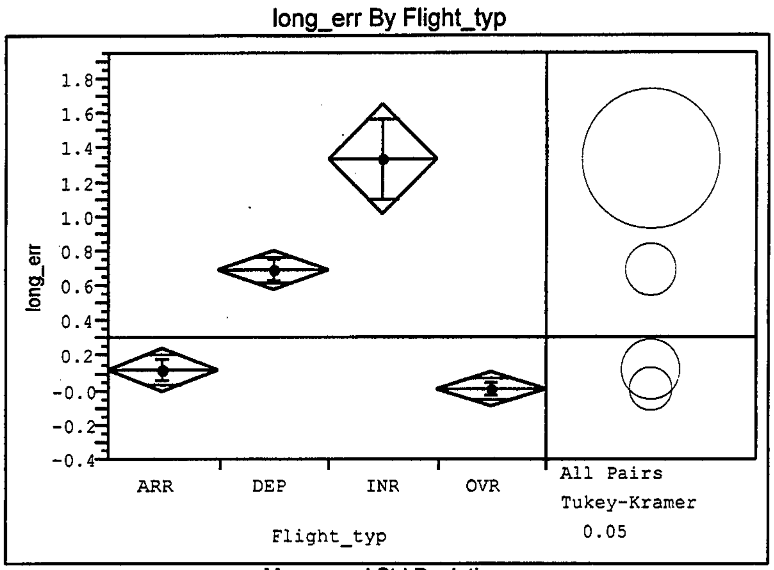
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3524	5.157907	3.064321	3.050366
DEP	4601	6.276126	3.837585	3.498012
INR	587	6.734253	3.831845	3.796311
OVR	6069	4.393789	1.846023	1.841193

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	39.4011	3	14777	<.0001
Brown-Forsythe	136.6233	3	14777	<.0001
Levene	193.4383	3	14777	<.0001
Bartlett	252.3342	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
64.7453	3	2536.2	<.0001

Figure A.2- 78 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3524	0.13325	4.05382	0.06829
DEP	4601	0.71609	4.65847	0.06868
INR	587	1.33758	5.86761	0.24218
OVR	6069	0.02175	3.46395	0.04446

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.00000	0.62149	1.20433	1.31583
DEP	-0.62149	0.00000	0.58284	0.69434
ARR	-1.20433	-0.58284	0.00000	0.11150
OVR	-1.31583	-0.69434	-0.11150	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56932

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-0.61774	0.157654	0.732544	0.858385
DEP	0.157654	-0.22065	0.345935	0.487465
ARR	0.732544	0.345935	-0.25212	-0.11264
OVR	0.858385	0.487465	-0.11264	-0.19212

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

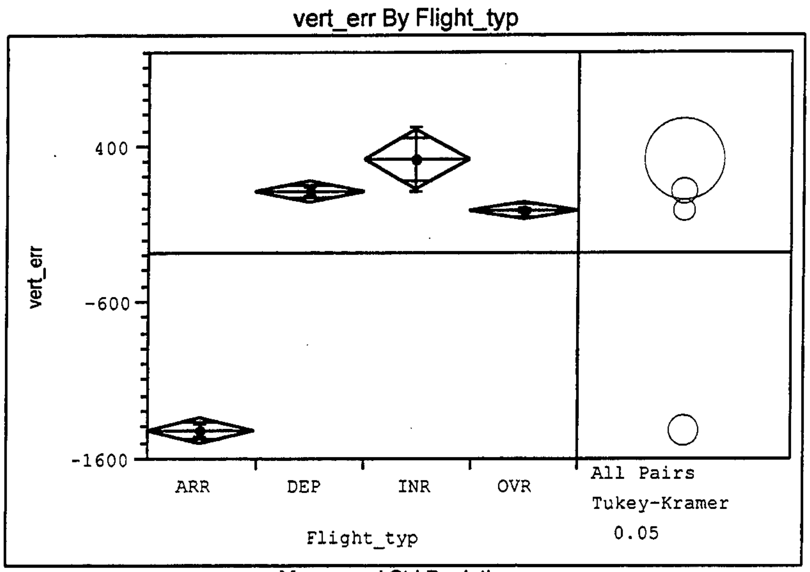
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3524	4.053821	2.466797	2.465175
DEP	4601	4.658474	3.302148	3.269237
INR	587	5.867611	3.990781	3.931556
OVR	6069	3.463951	2.016506	2.015870

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	33.1286	3	14777	<.0001
Brown-Forsythe	174.4498	3	14777	<.0001
Levene	187.8547	3	14777	<.0001
Bartlett	222.3397	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
31.6284	3	2521.5	<.0001

Figure A.2- 79 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	3524	-1413.52	3060.83	51.56
DEP	4601	125.61	2690.82	39.67
INR	587	322.53	5126.08	211.58
OVR	6069	-1.04	1404.76	18.03

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.00	196.93	323.57	1736.06
DEP	-196.93	0.00	126.64	1539.13
OVR	-323.57	-126.64	0.00	1412.48
ARR	-1736.06	-1539.13	-1412.48	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56932

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-377.62	-86.61	43.94	1447.66
DEP	-86.61	-134.88	0.18	1394.31
OVR	43.94	0.18	-117.44	1275.47
ARR	1447.66	1394.31	1275.47	-154.12

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

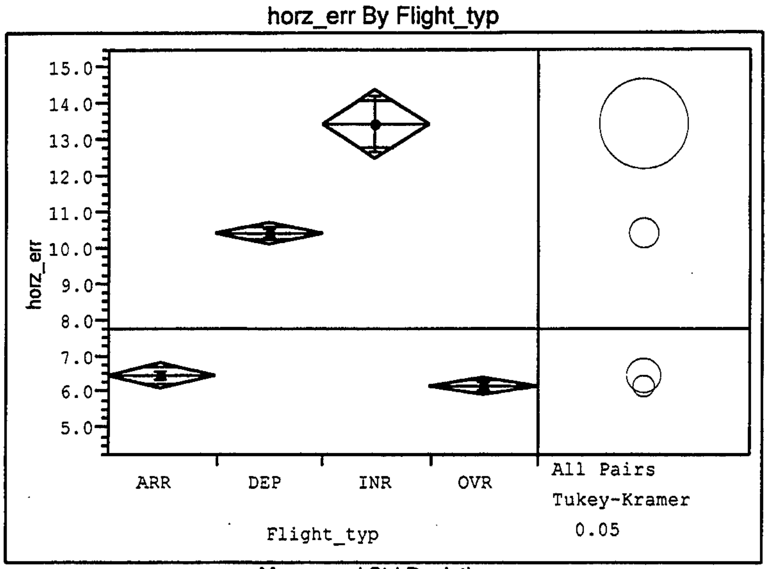
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	3524	3060.829	2252.792	1981.425
DEP	4601	2690.818	1465.116	1409.533
INR	587	5126.078	2868.165	2698.065
OVR	6069	1404.760	392.628	391.851

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	201.6230	3	14777	<.0001
Brown-Forsythe	517.0105	3	14777	0.0000
Levene	798.2990	3	14777	0.0000
Bartlett	1420.3592	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
238.2345	3	2394.6	<.0001

Figure A.2- 80 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1595	6.4839	6.4759	0.16215
DEP	2511	10.4451	8.2364	0.16437
INR	262	13.4387	13.1882	0.81477
OVR	3806	6.2038	8.2718	0.13408

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	ARR	OVR
INR	0.00000	2.99359	6.95483	7.23489
DEP	-2.99359	0.00000	3.96124	4.24130
ARR	-6.95483	-3.96124	0.00000	0.28006
OVR	-7.23489	-4.24130	-0.28006	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56956

Abs(Dif)-LSD	INR	DEP	ARR	OVR
INR	-1.83002	1.63373	5.55857	5.89707
DEP	1.63373	-0.59113	3.29058	3.70279
ARR	5.55857	3.29058	-0.74170	-0.34471
OVR	5.89707	3.70279	-0.34471	-0.48015

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1595	6.47587	4.409969	4.096753
DEP	2511	8.23636	6.431127	6.254751
INR	262	13.18822	9.319455	8.557274
OVR	3806	8.27178	5.267627	4.581328

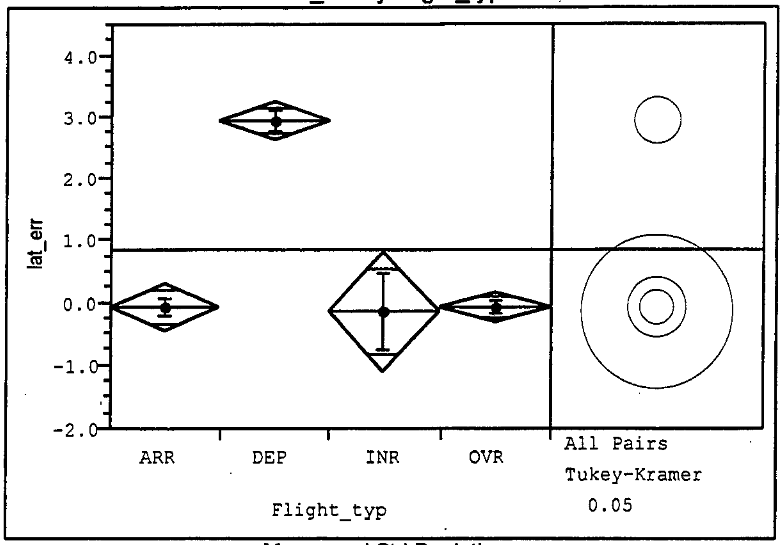
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	24.6861	3	8170	<.0001
Brown-Forsythe	66.9528	3	8170	<.0001
Levene	78.2751	3	8170	<.0001
Bartlett	106.2329	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
168.6419	3	1147.4	<.0001

Figure A.2- 81 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

lat_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1595	-0.05141	5.9488	0.14895
DEP	2511	2.94013	9.5544	0.19067
INR	262	-0.14939	10.0511	0.62096
OVR	3806	-0.05280	7.7632	0.12584

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	ARR	OVR	INR
DEP	0.00000	2.99153	2.99293	3.08951
ARR	-2.99153	0.00000	0.00139	0.09798
OVR	-2.99293	-0.00139	0.00000	0.09659
INR	-3.08951	-0.09798	-0.09659	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56956

Abs(Dif)-LSD	DEP	ARR	OVR	INR
DEP	-0.59024	2.32189	2.45524	1.73171
ARR	2.32189	-0.74058	-0.62242	-1.29617
OVR	2.45524	-0.62242	-0.47942	-1.23921
INR	1.73171	-1.29617	-1.23921	-1.82726

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1595	5.94877	3.592642	3.591725
DEP	2511	9.55439	6.622102	6.128857
INR	262	10.05110	5.673617	5.655618
OVR	3806	7.76318	3.226425	3.226131

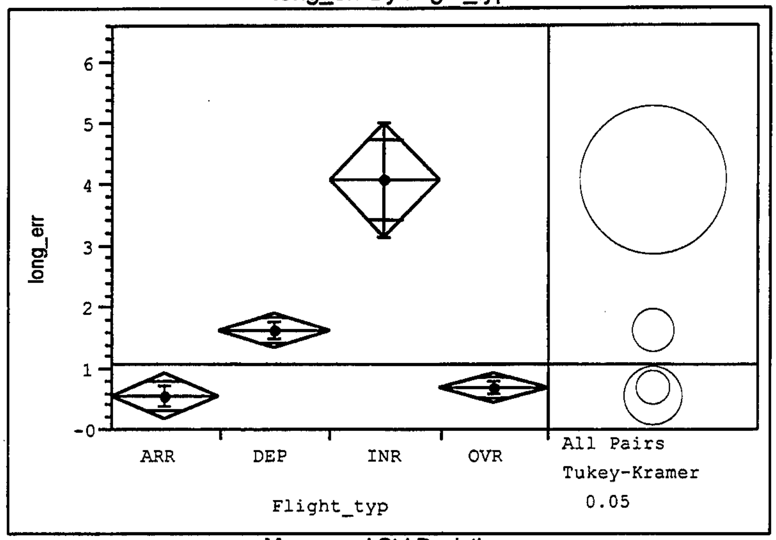
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	19.3541	3	8170	<.0001
Brown-Forsythe	96.5331	3	8170	<.0001
Levene	143.5206	3	8170	<.0001
Bartlett	148.0216	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
65.8062	3	1160.8	<.0001

Figure A.2- 82 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

long_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1595	0.19382	6.9697	0.17451
DEP	2511	1.30713	8.6798	0.17322
INR	262	3.71569	15.5021	0.95772
OVR	3806	0.32461	6.8224	0.11059

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.00000	2.40856	3.39107	3.52186
DEP	-2.40856	0.00000	0.98251	1.11331
OVR	-3.39107	-0.98251	0.00000	0.13079
ARR	-3.52186	-1.11331	-0.13079	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56956

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-1.76742	1.09522	2.09901	2.17336
DEP	1.09522	-0.57091	0.46243	0.46560
OVR	2.09901	0.46243	-0.46372	-0.47260
ARR	2.17336	0.46560	-0.47260	-0.71633

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1595	6.96966	4.38399	4.38362
DEP	2511	8.67979	6.52416	6.47047
INR	262	15.50208	10.61387	10.47426
OVR	3806	6.82238	4.00888	4.00871

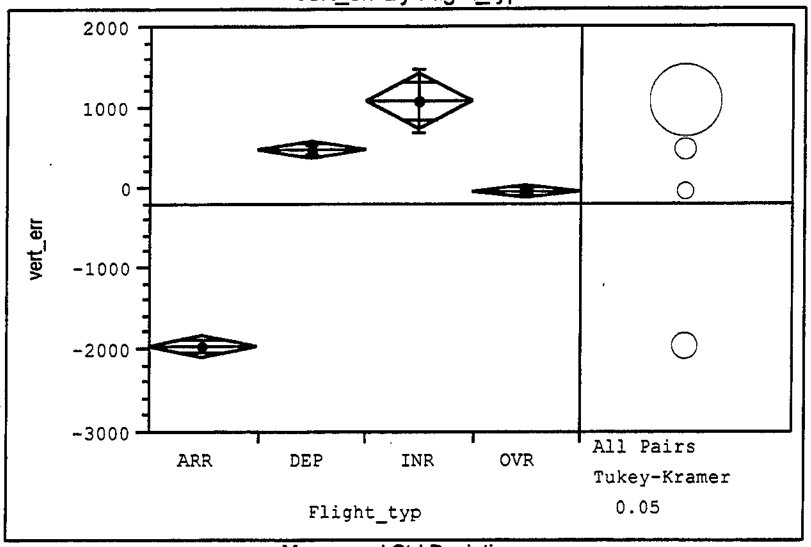
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	78.5880	3	8170	<.0001
Brown-Forsythe	168.9026	3	8170	<.0001
Levene	180.1406	3	8170	<.0001
Bartlett	211.2908	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
12.7640	3	1123.5	<.0001

Figure A.2- 83 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

vert_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	1595	-1946.08	3537.60	88.58
DEP	2511	507.25	3196.61	63.79
INR	262	1082.46	6391.57	394.87
OVR	3806	-26.60	1904.24	30.87

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.00	575.21	1109.06	3028.54
DEP	-575.21	0.00	533.85	2453.33
OVR	-1109.06	-533.85	0.00	1919.48
ARR	-3028.54	-2453.33	-1919.48	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.56956

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-657.41	86.70	628.47	2526.96
DEP	86.70	-212.36	340.40	2212.41
OVR	628.47	340.40	-172.49	1695.05
ARR	2526.96	2212.41	1695.05	-266.44

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

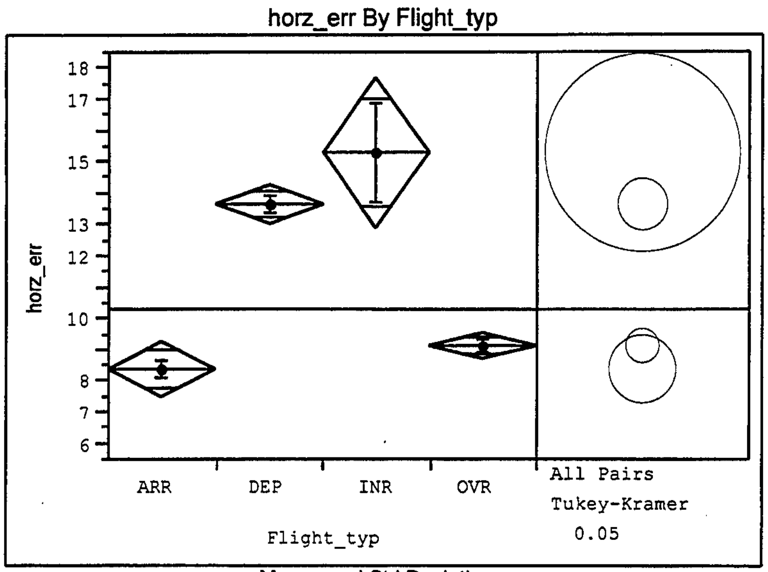
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	1595	3537.600	2717.032	2587.946
DEP	2511	3196.614	1763.663	1481.987
INR	262	6391.569	3902.425	3343.819
OVR	3806	1904.245	608.155	588.348

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	105.9061	3	8170	<.0001
Brown-Forsythe	291.0796	3	8170	<.0001
Levene	427.3650	3	8170	<.0001
Bartlett	607.8525	3	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
179.6429	3	1084.8	<.0001

Figure A.2- 84 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	568	8.3616	7.4698	0.3134
DEP	1051	13.6115	10.0271	0.3093
INR	76	15.3086	14.1192	1.6196
OVR	2217	9.1400	11.8309	0.2513

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.00000	1.69707	6.16858	6.94694
DEP	-1.69707	0.00000	4.47151	5.24987
OVR	-6.16858	-4.47151	0.00000	0.77836
ARR	-6.94694	-5.24987	-0.77836	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.57014

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-4.53485	-1.62347	2.90746	3.53252
DEP	-1.62347	-1.21946	3.42460	3.79407
OVR	2.90746	3.42460	-0.83963	-0.53629
ARR	3.53252	3.79407	-0.53629	-1.65881

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	568	7.46975	5.39484	5.07133
DEP	1051	10.02706	7.94571	7.84246
INR	76	14.11919	10.93628	10.26502
OVR	2217	11.83086	7.65672	6.71364

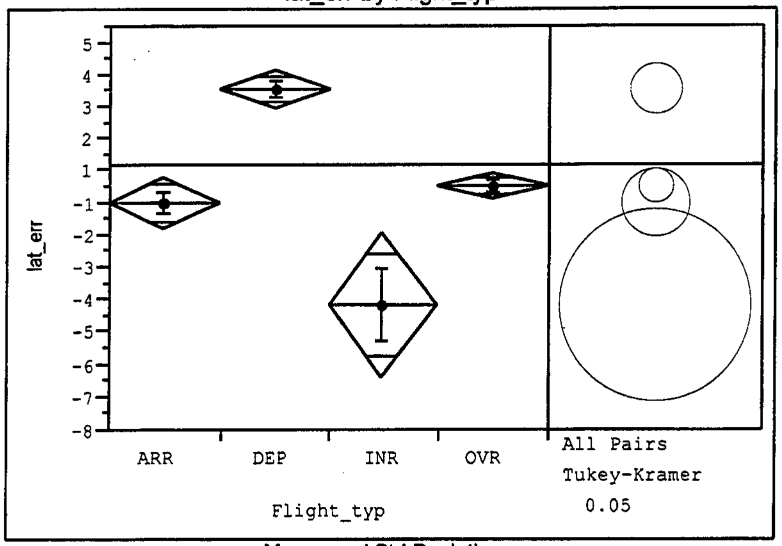
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	9.2485	3	3908	<.0001
Brown-Forsythe	15.2901	3	3908	<.0001
Levene	19.9114	3	3908	<.0001
Bartlett	61.5966	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
60.9921	3	342.04	<.0001

Figure A.2- 85 Statistical Tests for Horizontal Error and Flight Type at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

lat_err By Flight_typ



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	568	-0.49947	8.2107	0.3445
DEP	1051	3.07868	10.4293	0.3217
INR	76	-3.63685	9.8520	1.1301
OVR	2217	0.04260	10.5933	0.2250

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	ARR	INR
DEP	0.00000	3.03608	3.57815	6.71553
OVR	-3.03608	0.00000	0.54207	3.67945
ARR	-3.57815	-0.54207	0.00000	3.13738
INR	-6.71553	-3.67945	-3.13738	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.57014

Abs(Dif)-LSD	DEP	OVR	ARR	INR
DEP	-1.14612	2.05213	2.20991	3.59470
OVR	2.05213	-0.78913	-0.69351	0.61446
ARR	2.20991	-0.69351	-1.55904	-0.07168
INR	3.59470	0.61446	-0.07168	-4.26211

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

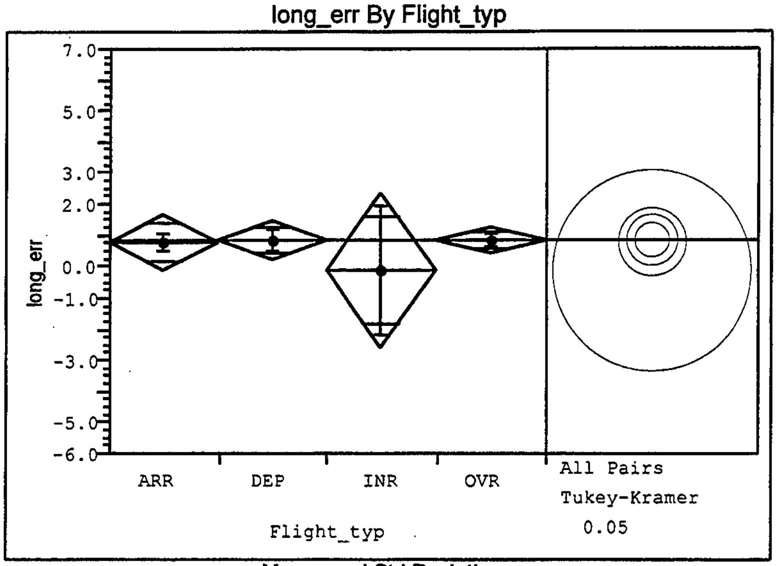
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	568	8.21067	4.950546	4.861906
DEP	1051	10.42935	7.087868	6.798501
INR	76	9.85200	6.609563	6.060208
OVR	2217	10.59330	4.557133	4.547427

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.6793	3	3908	0.1692
Brown-Forsythe	16.0530	3	3908	<.0001
Levene	21.2937	3	3908	<.0001
Bartlett	18.0091	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
29.7981	3	344.36	<.0001

Figure A.2- 86 Statistical Tests for Lateral Error and Flight Type at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	568	0.831732	7.5815	0.3181
DEP	1051	0.879796	12.9212	0.3986
INR	76	-0.08566	18.0653	2.0722
OVR	2217	0.862583	10.5158	0.2233

Means Comparisons

Dif=Mean[i]-Mean[j]	DEP	OVR	ARR	INR
DEP	0.000000	0.017213	0.048064	0.965453
OVR	-0.01721	0.000000	0.030851	0.948240
ARR	-0.04806	-0.03085	0.000000	0.917389
INR	-0.96545	-0.94824	-0.91739	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.57014

Abs(Dif)-LSD	DEP	OVR	ARR	INR
DEP	-1.23921	-1.04666	-1.43131	-2.40886
OVR	-1.04666	-0.85322	-1.30509	-2.36569
ARR	-1.43131	-1.30509	-1.68567	-2.55232
INR	-2.40886	-2.36569	-2.55232	-4.60828

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

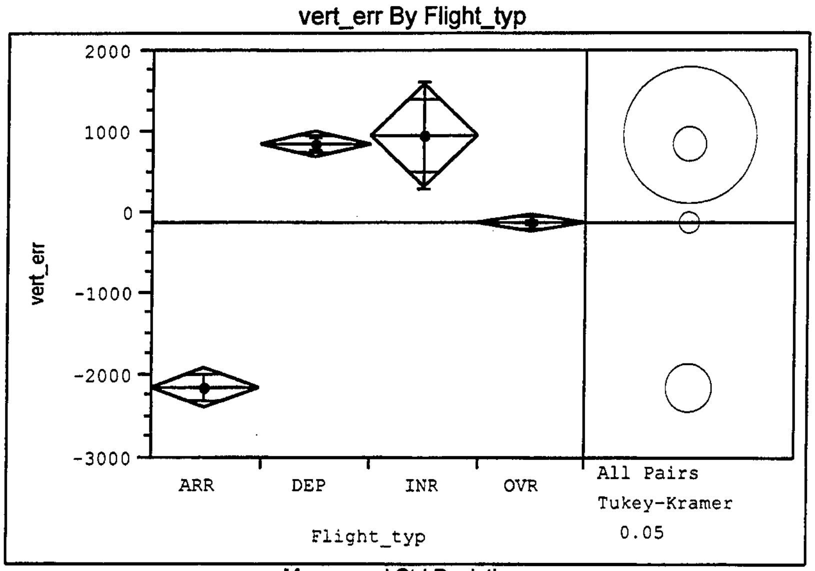
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	568	7.58151	5.39605	5.39570
DEP	1051	12.92122	9.68734	9.52229
INR	76	18.06533	12.12689	11.87389
OVR	2217	10.51581	6.09995	6.08753

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	21.4623	3	3908	<.0001
Brown-Forsythe	55.4863	3	3908	<.0001
Levene	62.1825	3	3908	<.0001
Bartlett	82.0415	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.0717	3	336.84	0.9751

Figure A.2- 87 Statistical Tests for Longitudinal Error and Flight Type at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ARR	568	-2134.48	4030.35	169.11
DEP	1051	854.48	3332.79	102.80
INR	76	954.04	5918.06	678.85
OVR	2217	-118.67	2096.60	44.53

Means Comparisons

Dif=Mean[i]-Mean[j]	INR	DEP	OVR	ARR
INR	0.00	99.56	1072.71	3088.51
DEP	-99.56	0.00	973.15	2988.95
OVR	-1072.71	-973.15	0.00	2015.80
ARR	-3088.51	-2988.95	-2015.80	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*=2.57014

Abs(Dif)-LSD	INR	DEP	OVR	ARR
INR	-1215.97	-790.81	198.27	2172.97
DEP	-790.81	-326.99	692.43	2598.60
OVR	198.27	692.43	-225.14	1663.30
ARR	2172.97	2598.60	1663.30	-444.79

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ARR	568	4030.345	3168.840	3059.420
DEP	1051	3332.793	2010.625	1601.063
INR	76	5918.064	4046.664	3628.069
OVR	2217	2096.601	813.231	724.523

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	43.6092	3	3908	<.0001
Brown-Forsythe	157.1113	3	3908	<.0001
Levene	214.4960	3	3908	<.0001
Bartlett	236.1195	3	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
77.4440	3	322.02	<.0001

Figure A.2- 88 Statistical Tests for Vertical Error and Flight Type at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

A.2.3 Horizaontal Phase of Flight Per Look Ahead Time

A.2.3.1 Summary Tables

Look Ahead Time	0		300	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	27295	5314	22892	4271
Avg. Horz. Error	0.26	0.33	2.59	2.88
Stddev. Horz. Error	0.83	0.92	3.18	3.28
Max. Horz. Error	48.02	25.79	88.45	32.87
Min. Horz. Error	0	0	0	0.01
Avg. Lat. Error	0	0	0.05	-0.12
Stddev. Lat. Error	0.46	0.44	3.29	3.36
Max. Lat. Error	22.88	11.48	46.61	20.75
Min. Lat. Error	-15.57	-8.26	-46.12	-30.48
Avg. Abs. Lat. Error	0.12	0.17	1.71	1.83
Stddev. Abs. Lat. Error	0.44	0.4	2.81	2.82
Max. Abs. Lat. Error	22.88	11.48	46.61	30.48
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.04	-0.11	-0.03	-0.23
Stddev. Long. Error	0.74	0.87	2.44	2.77
Max. Long. Error	47.54	17.84	46.01	22.74
Min. Long. Error	-31.16	-23.09	-87.99	-26.03
Avg. Abs. Long. Error	0.2	0.24	1.44	1.72
Stddev. Abs. Long. Error	0.72	0.85	1.98	2.19
Max. Abs. Long. Error	47.54	23.09	87.99	26.03
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-92.51	-131.26	-487.15	-746.29
Stddev. Vert. Error	767.14	894.17	2132.89	2287.29
Max. Vert. Error	18889	5200	27290	16460.38
Min. Vert. Error	-31025	-31466.5	-24677	-17950
Avg. Abs. Vert. Error	149	179.68	1021.07	1278.96
Stddev. Abs. Vert. Error	758.19	885.71	1934.92	2037.81
Max. Abs. Vert. Error	31025	31466.46	27290	17950
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	0.27	0.34	2.62	2.91
Stddev. Slant Range Error	0.84	0.93	3.18	3.27
Max. Slant Range Error	48.03	25.79	88.56	32.89
Min. Slant Range Error	0	0	0.01	0.01

Figure A.2- 89 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	600		900	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	18406	3502	14224	2717
Avg. Horz. Error	4.42	5.1	6.1	6.78
Stddev. Horz. Error	4.85	5.44	6.38	7.41
Max. Horz. Error	67.08	65.69	85.13	101.09
Min. Horz. Error	0.01	0.02	0.01	0.05
Avg. Lat. Error	0.27	0.05	0.5	0.25
Stddev. Lat. Error	4.94	5.5	6.24	6.78
Max. Lat. Error	55.5	38.94	60.84	54.78
Min. Lat. Error	-38.27	-34.2	-43.96	-64.27
Avg. Abs. Lat. Error	2.6	2.97	3.28	3.62
Stddev. Abs. Lat. Error	4.21	4.63	5.34	5.73
Max. Abs. Lat. Error	55.5	38.94	60.84	64.27
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.35	0.01	0.7	0.34
Stddev. Long. Error	4.3	5.04	6.18	7.4
Max. Long. Error	59.63	25.83	49.55	58.31
Min. Long. Error	-59.4	-59.56	-76.98	-83.04
Avg. Abs. Long. Error	2.75	3.25	4.05	4.6
Stddev. Abs. Long. Error	3.32	3.85	4.72	5.8
Max. Abs. Long. Error	59.63	59.56	76.98	83.04
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-684.1	-1157.81	-793.99	-1535.62
Stddev. Vert. Error	2795.7	3059.21	3330.87	3437.51
Max. Vert. Error	28990	15000	29003	18825
Min. Vert. Error	-26868	-23629.6	-32426	-21566
Avg. Abs. Vert. Error	1436.1	1859.4	1701.93	2222.37
Stddev. Abs. Vert. Error	2494.28	2690.97	2971.26	3038.87
Max. Abs. Vert. Error	28990	23629.62	32426	21566
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	4.45	5.14	6.14	6.83
Stddev. Slant Range Error	4.84	5.42	6.37	7.39
Max. Slant Range Error	67.09	65.69	85.13	101.09
Min. Slant Range Error	0.01	0.04	0.01	0.06

Figure A.2- 90 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1200		1500	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	10850	2071	7738	1523
Avg. Horz. Error	7.78	8.03	9.37	9.56
Stddev. Horz. Error	8.05	8.45	9.8	9.53
Max. Horz. Error	82.64	103.04	94.14	66.7
Min. Horz. Error	0.01	0.08	0.03	0.09
Avg. Lat. Error	0.57	0.51	0.53	0.12
Stddev. Lat. Error	7.52	7.14	8.67	7.88
Max. Lat. Error	76.1	51.81	85.67	58.08
Min. Lat. Error	-55.56	-46.57	-65.63	-58.18
Avg. Abs. Lat. Error	3.92	3.87	4.46	4.17
Stddev. Abs. Lat. Error	6.44	6.01	7.46	6.68
Max. Abs. Lat. Error	76.1	51.81	85.67	58.18
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	1.21	1.11	1.75	2.38
Stddev. Long. Error	8.19	9.14	10.26	10.7
Max. Long. Error	77.59	53.21	94.14	52.7
Min. Long. Error	-74.98	-94.35	-73.71	-64.82
Avg. Abs. Long. Error	5.4	5.78	6.7	7.25
Stddev. Abs. Long. Error	6.28	7.16	7.96	8.22
Max. Abs. Long. Error	77.59	94.35	94.14	64.82
Min. Abs. Long. Error	0	0	0	0.01
Avg. Vert. Error	-933.03	-1681.97	-1012.68	-1853.79
Stddev. Vert. Error	3506.8	3884.51	3697.58	3615.68
Max. Vert. Error	29003	28590	29003	12988
Min. Vert. Error	-28868	-26558	-27901	-21608.7
Avg. Abs. Vert. Error	1837.68	2481.46	1941.86	2467.18
Stddev. Abs. Vert. Error	3129.04	3429.17	3305.51	3228.16
Max. Abs. Vert. Error	29003	28590	29003	21608.72
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	7.82	8.08	9.41	9.6
Stddev. Slant Range Error	8.04	8.43	9.79	9.51
Max. Slant Range Error	82.64	103.05	94.14	66.71
Min. Slant Range Error	0.01	0.08	0.03	0.09

Figure A.2- 91 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1800			
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	5538	1119		
Avg. Horz. Error	10.92	11.04		
Stddev. Horz. Error	11.25	11.07		
Max. Horz. Error	98.82	80.1		
Min. Horz. Error	0.03	0.14		
Avg. Lat. Error	0.4	0.72		
Stddev. Lat. Error	9.5	8.82		
Max. Lat. Error	86.54	80.05		
Min. Lat. Error	-62.21	-51.12		
Avg. Abs. Lat. Error	4.92	4.63		
Stddev. Abs. Lat. Error	8.14	7.54		
Max. Abs. Lat. Error	86.54	80.05		
Min. Abs. Lat. Error	0	0		
Avg. Long. Error	2.23	3.41		
Stddev. Long. Error	12.26	12.43		
Max. Long. Error	96.86	62.4		
Min. Long. Error	-78.6	-64.47		
Avg. Abs. Long. Error	8.06	8.45		
Stddev. Abs. Long. Error	9.5	9.74		
Max. Abs. Long. Error	96.86	64.47		
Min. Abs. Long. Error	0	0.01		
Avg. Vert. Error	-1147.78	-1854.55		
Stddev. Vert. Error	3829.33	4008.78		
Max. Vert. Error	29003	16996		
Min. Vert. Error	-29635	-25934		
Avg. Abs. Vert. Error	2075.72	2597.2		
Stddev. Abs. Vert. Error	3416.44	3572.29		
Max. Abs. Vert. Error	29635	25934		
Min. Abs. Vert. Error	0	0		
Avg. Slant Range Error	10.95	11.08		
Stddev. Slant Range Error	11.23	11.05		
Max. Slant Range Error	98.82	80.1		
Min. Slant Range Error	0.03	0.14		

Figure A.2- 92 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	0		300	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	18689	2520	16359	2092
Avg. Horz. Error	0.23	0.36	2.46	2.87
Stddev. Horz. Error	0.71	1.01	3.29	3.46
Max. Horz. Error	48.02	25.79	88.45	32.87
Min. Horz. Error	0	0	0	0.01
Avg. Lat. Error	0	0	0.08	-0.13
Stddev. Lat. Error	0.4	0.46	3.41	3.78
Max. Lat. Error	22.88	11.48	46.61	20.75
Min. Lat. Error	-15.57	-8.26	-46.12	-30.48
Avg. Abs. Lat. Error	0.1	0.19	1.68	1.97
Stddev. Abs. Lat. Error	0.39	0.43	2.98	3.22
Max. Abs. Lat. Error	22.88	11.48	46.61	30.48
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	-0.03	-0.12	0.06	-0.05
Stddev. Long. Error	0.63	0.95	2.28	2.43
Max. Long. Error	47.54	17.84	46.01	10.03
Min. Long. Error	-31.16	-23.09	-87.99	-16.55
Avg. Abs. Long. Error	0.18	0.26	1.29	1.55
Stddev. Abs. Long. Error	0.6	0.93	1.88	1.87
Max. Abs. Long. Error	47.54	23.09	87.99	16.55
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-13.84	-44.2	-115.47	-361.89
Stddev. Vert. Error	485.48	593.33	1728.77	2112.63
Max. Vert. Error	18889	5200	27290	14600
Min. Vert. Error	-21500	-16406.8	-18228	-17950
Avg. Abs. Vert. Error	69.58	93.34	698.19	1021.31
Stddev. Abs. Vert. Error	480.67	587.61	1585.71	1884.32
Max. Abs. Vert. Error	21500	16406.83	27290	17950
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	0.24	0.36	2.48	2.89
Stddev. Slant Range Error	0.72	1.01	3.29	3.45
Max. Slant Range Error	48.03	25.79	88.56	32.89
Min. Slant Range Error	0	0	0.01	0.01

Figure A.2- 93 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	600		900	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	13146	1661	10001	1216
Avg. Horz. Error	4.29	5.34	6.04	6.84
Stddev. Horz. Error	5.04	5.91	6.62	7.81
Max. Horz. Error	67.08	43.12	75.25	58.36
Min. Horz. Error	0.01	0.02	0.01	0.09
Avg. Lat. Error	0.36	0.07	0.71	0.31
Stddev. Lat. Error	5.21	6.43	6.75	8.08
Max. Lat. Error	55.5	38.94	60.84	54.78
Min. Lat. Error	-38.27	-34.2	-43.96	-38.45
Avg. Abs. Lat. Error	2.63	3.46	3.45	4.26
Stddev. Abs. Lat. Error	4.51	5.42	5.84	6.88
Max. Abs. Lat. Error	55.5	38.94	60.84	54.78
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.34	0.1	0.49	-0.06
Stddev. Long. Error	4.06	4.71	5.84	6.51
Max. Long. Error	59.63	23.35	49.55	58.31
Min. Long. Error	-29.72	-22.22	-61.99	-29.54
Avg. Abs. Long. Error	2.54	3.07	3.76	4.07
Stddev. Abs. Long. Error	3.18	3.57	4.49	5.08
Max. Abs. Long. Error	59.63	23.35	61.99	58.31
Min. Abs. Long. Error	0	0	0	0
Avg. Vert. Error	-227.61	-738.37	-170.96	-1060.4
Stddev. Vert. Error	2513.8	3125.02	2919.33	3630.59
Max. Vert. Error	28990	15000	29003	18825
Min. Vert. Error	-16708	-16406.8	-20550	-19945.7
Avg. Abs. Vert. Error	1106.31	1740.02	1259.94	2077.59
Stddev. Abs. Vert. Error	2268.69	2698.48	2638.96	3160.17
Max. Abs. Vert. Error	28990	16406.83	29003	19945.74
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	4.32	5.38	6.07	6.9
Stddev. Slant Range Error	5.03	5.9	6.62	7.78
Max. Slant Range Error	67.09	43.12	75.4	58.36
Min. Slant Range Error	0.01	0.04	0.01	0.09

Figure A.2- 94 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

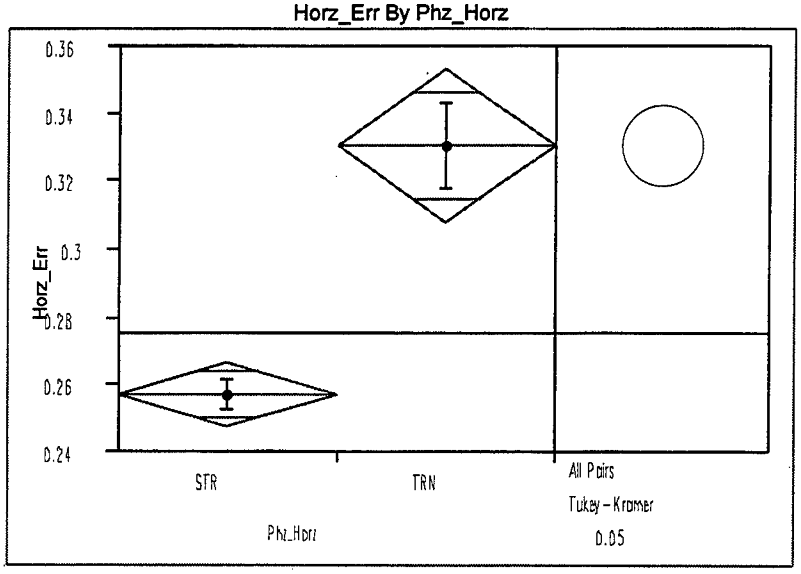
Look Ahead Time	1200		1500	
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	7290	899	5065	640
Avg. Horz. Error	7.75	8.12	9.15	8.98
Stddev. Horz. Error	8.35	9.03	9.89	9.37
Max. Horz. Error	78.4	86.73	87.22	66.7
Min. Horz. Error	0.01	0.08	0.03	0.09
Avg. Lat. Error	0.88	0.71	0.88	-0.15
Stddev. Lat. Error	8.26	8.16	9.53	9.13
Max. Lat. Error	76.1	51.81	85.67	58.08
Min. Lat. Error	-55.56	-46.57	-65.63	-58.18
Avg. Abs. Lat. Error	4.25	4.43	4.81	4.93
Stddev. Abs. Lat. Error	7.14	6.89	8.27	7.68
Max. Abs. Lat. Error	76.1	51.81	85.67	58.18
Min. Abs. Lat. Error	0	0	0	0
Avg. Long. Error	0.76	0.21	0.84	0.52
Stddev. Long. Error	7.76	8.97	9.45	9.21
Max. Long. Error	77.59	53.21	63.91	45.31
Min. Long. Error	-48.76	-85.87	-61.99	-43.79
Avg. Abs. Long. Error	5.02	5.37	6.11	5.95
Stddev. Abs. Long. Error	5.97	7.18	7.26	7.04
Max. Abs. Long. Error	77.59	85.87	63.91	45.31
Min. Abs. Long. Error	0	0.03	0	0.01
Avg. Vert. Error	-122.61	-837.67	-87.3	-920.05
Stddev. Vert. Error	2952.86	3769.17	2915.69	3442.38
Max. Vert. Error	29003	28590	29003	12988
Min. Vert. Error	-19633	-17533	-20550	-19924.8
Avg. Abs. Vert. Error	1255.15	2063.47	1248.58	1902.22
Stddev. Abs. Vert. Error	2675.6	3262.89	2636.21	3012.25
Max. Abs. Vert. Error	29003	28590	29003	19924.8
Min. Abs. Vert. Error	0	0	0	0
Avg. Slant Range Error	7.78	8.16	9.17	9.02
Stddev. Slant Range Error	8.34	9.01	9.88	9.35
Max. Slant Range Error	78.4	86.86	87.23	66.71
Min. Slant Range Error	0.01	0.08	0.03	0.09

Figure A.2- 95 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	1800			
Horizontal Phase of Flight	Straight	Turn	Straight	Turn
Sample Quantity	3471	446		
Avg. Horz. Error	10.24	11.15		
Stddev. Horz. Error	10.95	12.07		
Max. Horz. Error	87.65	80.1		
Min. Horz. Error	0.03	0.16		
Avg. Lat. Error	0.74	0.46		
Stddev. Lat. Error	10.21	11.2		
Max. Lat. Error	86.54	80.05		
Min. Lat. Error	-62.21	-51.12		
Avg. Abs. Lat. Error	5.16	5.87		
Stddev. Abs. Lat. Error	8.84	9.54		
Max. Abs. Lat. Error	86.54	80.05		
Min. Abs. Lat. Error	0	0		
Avg. Long. Error	0.74	1.57		
Stddev. Long. Error	10.93	11.92		
Max. Long. Error	77.47	52.26		
Min. Long. Error	-58.65	-36.95		
Avg. Abs. Long. Error	7	7.46		
Stddev. Abs. Long. Error	8.42	9.42		
Max. Abs. Long. Error	77.47	52.26		
Min. Abs. Long. Error	0	0.01		
Avg. Vert. Error	-65.69	-620.82		
Stddev. Vert. Error	2979.91	3577.84		
Max. Vert. Error	29003	16996		
Min. Vert. Error	-17851	-16883		
Avg. Abs. Vert. Error	1289.48	1900.28		
Stddev. Abs. Vert. Error	2687.17	3093.23		
Max. Abs. Vert. Error	29003	16996		
Min. Abs. Vert. Error	0	0		
Avg. Slant Range Error	10.26	11.18		
Stddev. Slant Range Error	10.94	12.06		
Max. Slant Range Error	87.65	80.1		
Min. Slant Range Error	0.03	0.16		

Figure A.2- 96 Descriptive Statistics for Horizontal Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

A.2.3.2 Statistical Tests



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	27264	0.264519	0.833229	0.00505
TRN	5295	0.331566	0.926179	0.01273

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.067046
STR	-0.06705	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96004

Abs(Dif)-LSD	TRN	STR
TRN	-0.03234	0.042055
STR	0.042055	-0.01425

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	27264	0.8332289	0.2365059	0.1939988
TRN	5295	0.9261793	0.3046642	0.2557873

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.3673	1	32557	0.5445
Brown-Forsythe	24.2398	1	32557	<.0001
Levene	31.2597	1	32557	<.0001
Bartlett	103.9422	1	?	<.0001

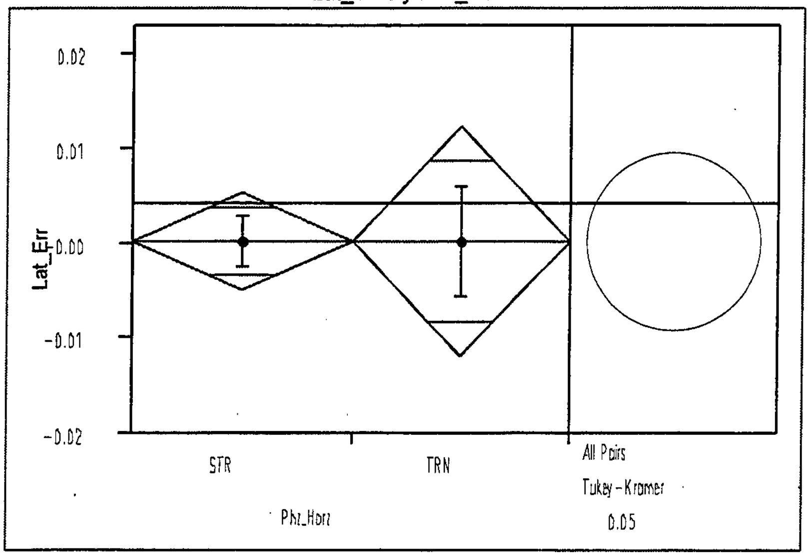
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
23.9786	1	7055.2	<.0001

t-Test
4.8968

Figure A.2- 97 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	27264	0.000231	0.457736	0.00277
TRN	5295	0.001114	0.436308	0.00600

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.000884
STR	-0.00088	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96004

Abs(Dif)-LSD	TRN	STR
TRN	-0.01731	-0.01249
STR	-0.01249	-0.00763

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	27264	0.4577364	0.1178316	0.1178224
TRN	5295	0.4363083	0.1693752	0.1693221

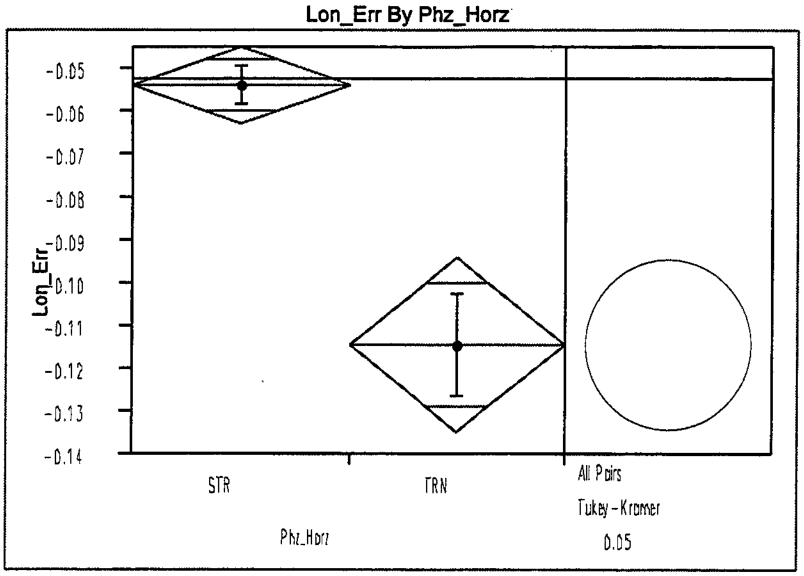
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0695	1	32557	0.7921
Brown-Forsythe	61.8537	1	32557	<.0001
Levene	61.9610	1	32557	<.0001
Bartlett	19.9428	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.0179	1	7730.6	0.8936

t-Test
0.1338

Figure A.2- 98 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	27264	-0.0385	0.743800	0.00450
TRN	5295	-0.10702	0.875181	0.01203

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.068517
TRN	-0.06852	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96004

Abs(Dif)-LSD	STR	TRN
STR	-0.01287	0.045949
TRN	0.045949	-0.02921

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	27264	0.7437996	0.1995113	0.1995111
TRN	5295	0.8751809	0.2347585	0.2290639

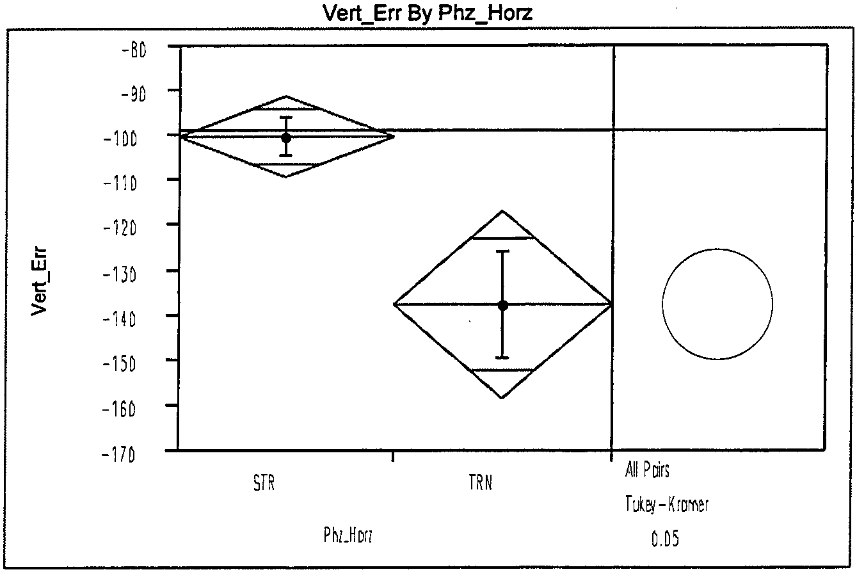
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.7503	1	32557	0.3864
Brown-Forsythe	7.0894	1	32557	0.0078
Levene	10.0976	1	32557	0.0015
Bartlett	252.0478	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
28.4616	1	6857.2	<.0001

t-Test
5.3349

Figure A.2- 99 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	27264	-92.649	767.552	4.649
TRN	5295	-130.028	887.590	12.198

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.0000	37.3792
TRN	-37.3792	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96004

Abs(Dif)-LSD	STR	TRN
STR	-13.2338	14.1746
TRN	14.1746	-30.0295

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	27264	767.5522	197.5797	149.1224
TRN	5295	887.5899	241.5362	178.5519

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.0469	1	32557	0.3062
Brown-Forsythe	6.3205	1	32557	0.0119
Levene	14.7896	1	32557	0.0001
Bartlett	199.6234	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

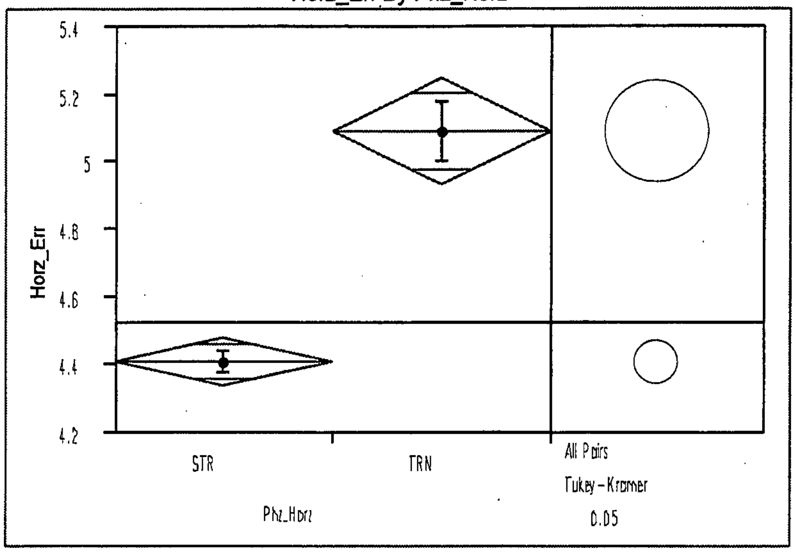
F Ratio	DF Num	DF Den	Prob>F
8.1999	1	6915.1	0.0042

t-Test

2.8635

Figure A.2- 100 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Horz_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18383	4.41936	4.85142	0.03578
TRN	3496	5.09933	5.43096	0.09185

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.679975
STR	-0.67998	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	TRN	STR
TRN	-0.232	0.501009
STR	0.501009	-0.10117

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18383	4.851417	3.377828	3.094611
TRN	3496	5.430962	3.812087	3.516101

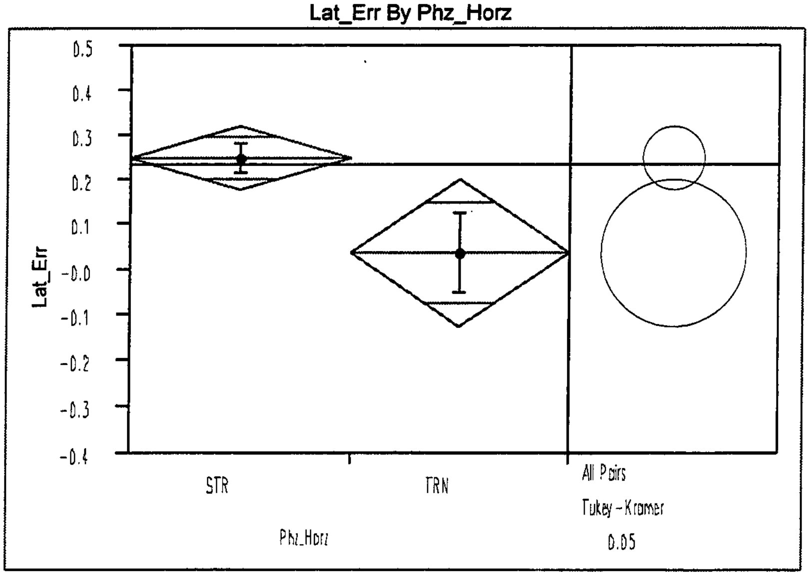
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	11.9422	1	21877	0.0005
Brown-Forsythe	30.2115	1	21877	<.0001
Levene	44.0381	1	21877	<.0001
Bartlett	78.6677	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
47.5822	1	4616	<.0001
t-Test			
6.8980			

Figure A.2- 101 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18383	0.271442	4.93684	0.03641
TRN	3496	0.050082	5.50190	0.09305

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.221360
TRN	-0.22136	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	STR	TRN
STR	-0.10286	0.039398
TRN	0.039398	-0.23588

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18383	4.936844	2.643731	2.595941
TRN	3496	5.501902	2.977712	2.975884

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	12.2004	1	21877	0.0005
Brown-Forsythe	23.1718	1	21877	<.0001
Levene	18.1775	1	21877	<.0001
Bartlett	72.4041	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

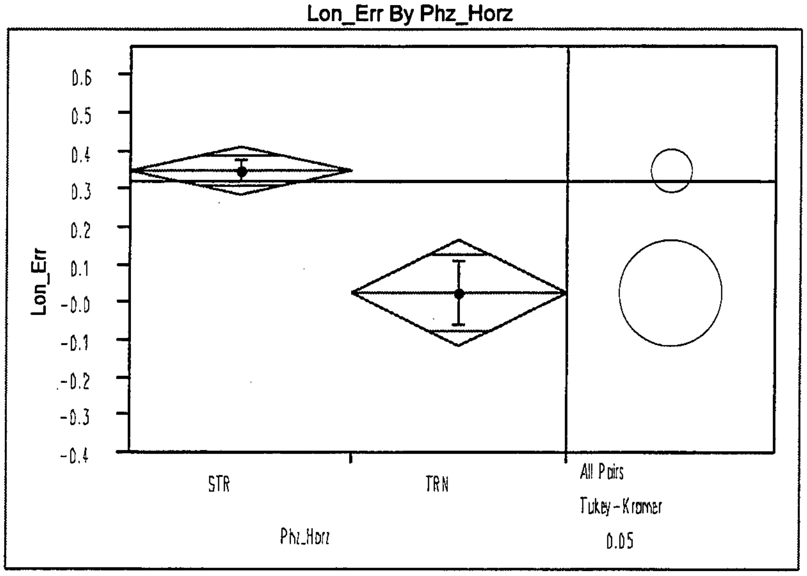
F Ratio	DF Num	DF Den	Prob>F
4.9076	1	4626.6	0.0268

t-Test

2.2153

Figure A.2- 102 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18383	0.349696	4.30111	0.03172
TRN	3496	0.001907	5.02320	0.08496

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.347789
TRN	-0.34779	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	STR	TRN
STR	-0.09046	0.187780
TRN	0.187780	-0.20742

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18383	4.301115	2.744387	2.741431
TRN	3496	5.023198	3.238126	3.236695

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	24.9127	1	21877	<.0001
Brown-Forsythe	62.1081	1	21877	<.0001
Levene	61.8858	1	21877	<.0001
Bartlett	151.5898	1	?	<.0001

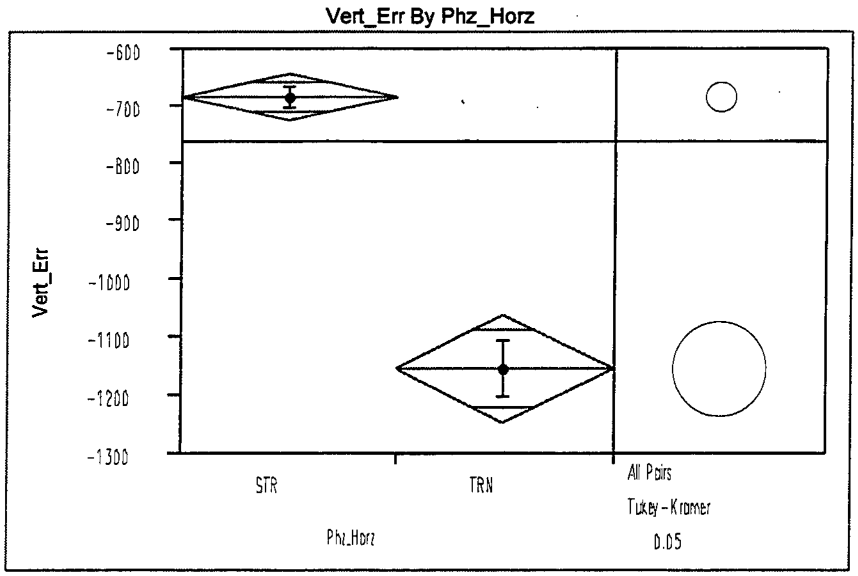
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.7081	1	4520.9	0.0001

t-Test

3.8351

Figure A.2- 103 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18383	-684.67	2796.76	20.628
TRN	3496	-1151.68	3046.70	51.528

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000	467.004
TRN	-467.004	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96007

Abs(Dif)-LSD	STR	TRN
STR	-58.025	364.360
TRN	364.360	-133.058

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18383	2796.759	1727.401	1437.303
TRN	3496	3046.698	2138.179	1854.463

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	8.4916	1	21877	0.0036
Brown-Forsythe	80.1809	1	21877	<.0001
Levene	102.8909	1	21877	<.0001
Bartlett	44.7184	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

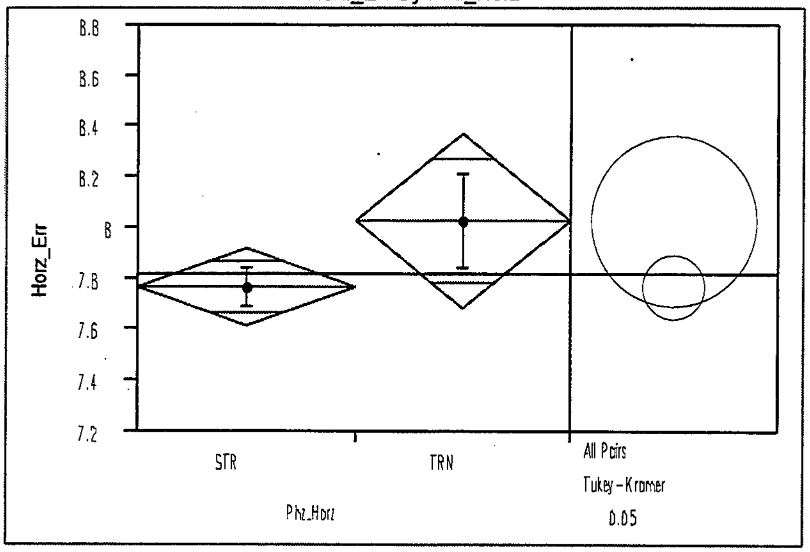
F Ratio	DF Num	DF Den	Prob>F
70.7946	1	4682.1	<.0001

t-Test

8.4140

Figure A.2- 104 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Horz_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	10835	7.78408	8.05411	0.07738
TRN	2071	8.02718	8.45143	0.18571

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.243101
STR	-0.2431	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96015

Abs(Dif)-LSD	TRN	STR
TRN	-0.49457	-0.13857
STR	-0.13857	-0.21622

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	10835	8.054112	5.778909	5.349948
TRN	2071	8.451432	6.002259	5.569880

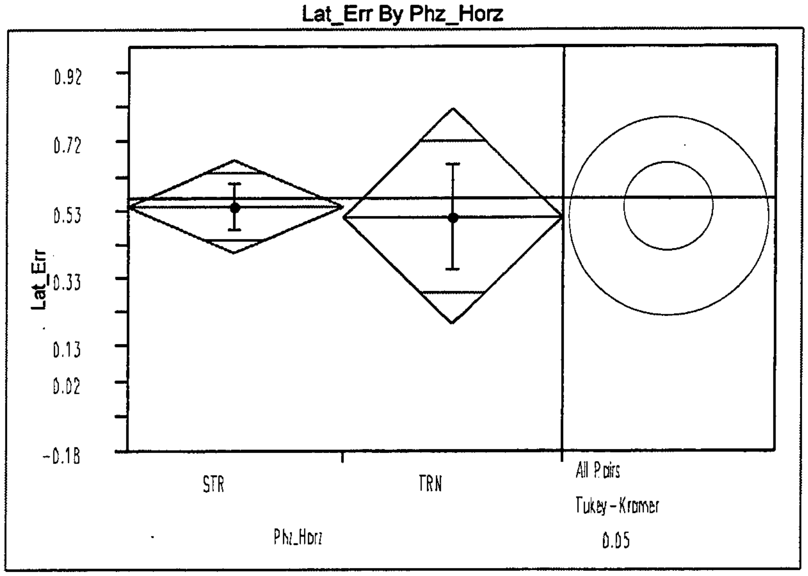
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.3686	1	12904	0.2421
Brown-Forsythe	1.8934	1	12904	0.1688
Levene	2.7022	1	12904	0.1002
Bartlett	8.2351	1	?	0.0041

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.4601	1	2834.7	0.2270

t-Test
1.2083

Figure A.2- 105 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	10835	0.571675	7.52091	0.07225
TRN	2071	0.511069	7.13722	0.15683

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.060605
TRN	-0.06061	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96015

Abs(Dif)-LSD	STR	TRN
STR	-0.19869	-0.29011
TRN	-0.29011	-0.45446

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	10835	7.520910	4.054863	3.925750
TRN	2071	7.137216	3.953829	3.874962

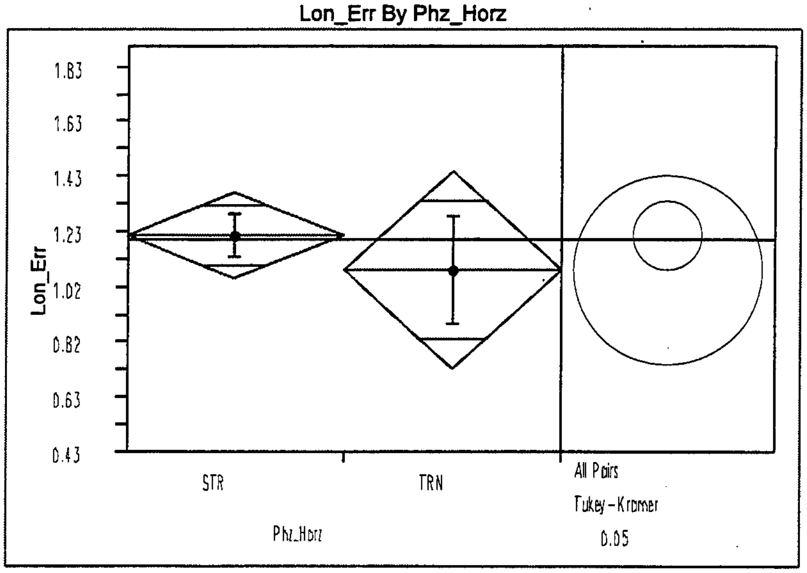
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.2475	1	12904	0.2641
Brown-Forsythe	0.1104	1	12904	0.7397
Levene	0.4511	1	12904	0.5018
Bartlett	9.3052	1	?	0.0023

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.1232	1	3016	0.7256

t-Test
0.3510

Figure A.2- 106 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	10835	1.21619	8.19122	0.07869
TRN	2071	1.10775	9.13590	0.20075

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.108443
TRN	-0.10844	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96015

Abs(Dif)-LSD	STR	TRN
STR	-0.22237	-0.28408
TRN	-0.28408	-0.50863

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	10835	8.191218	5.376988	5.352639
TRN	2071	9.135898	5.759456	5.745554

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	8.8611	1	12904	0.0029
Brown-Forsythe	6.6045	1	12904	0.0102
Levene	6.3391	1	12904	0.0118
Bartlett	43.4774	1	?	<.0001

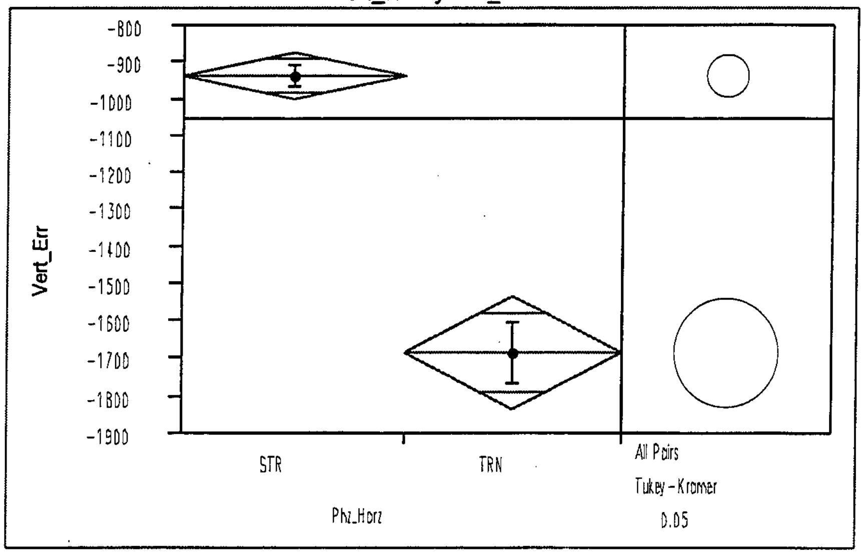
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.2529	1	2742.6	0.6151

t-Test
0.5029

Figure A.2- 107 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Vert_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	10835	-934.42	3509.02	33.711
TRN	2071	-1681.97	3884.51	85.358

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000	747.554
TRN	-747.554	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96015

Abs(Dif)-LSD	STR	TRN
STR	-95.124	579.642
TRN	579.642	-217.578

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

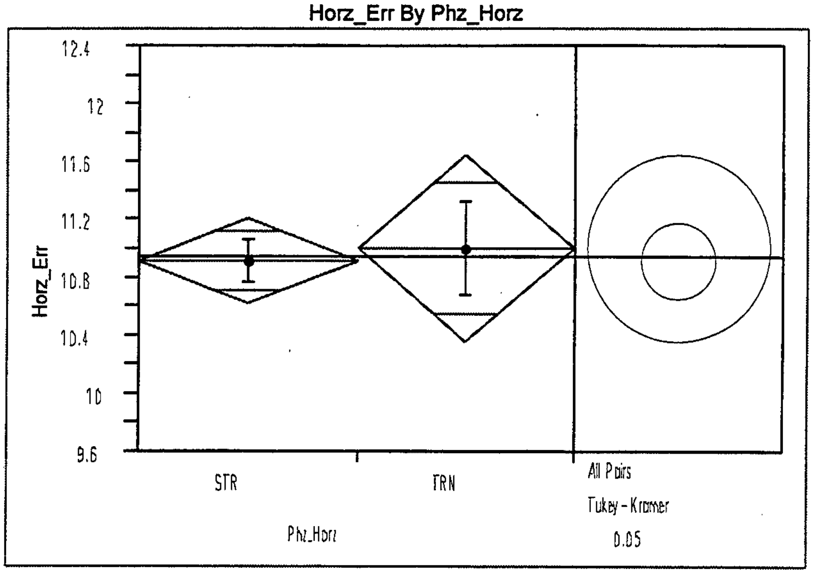
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	10835	3509.019	2212.443	1840.122
TRN	2071	3884.508	2788.978	2480.770

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	7.6384	1	12904	0.0057
Brown-Forsythe	70.6209	1	12904	<.0001
Levene	78.0962	1	12904	<.0001
Bartlett	37.5909	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
66.3506	1	2753.3	<.0001
t-Test			
8.1456			

Figure A.2- 108 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5533	10.9251	11.2512	0.15126
TRN	1119	11.0378	11.0722	0.33099

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.112691
STR	-0.11269	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96032

Abs(Dif)-LSD	TRN	STR
TRN	-0.92997	-0.60834
STR	-0.60834	-0.41822

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5533	11.25121	8.199874	7.558824
TRN	1119	11.07216	8.289999	7.573824

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.1083	1	6650	0.7421
Brown-Forsythe	0.0025	1	6650	0.9603
Levene	0.1294	1	6650	0.7190
Bartlett	0.4752	1	?	0.4906

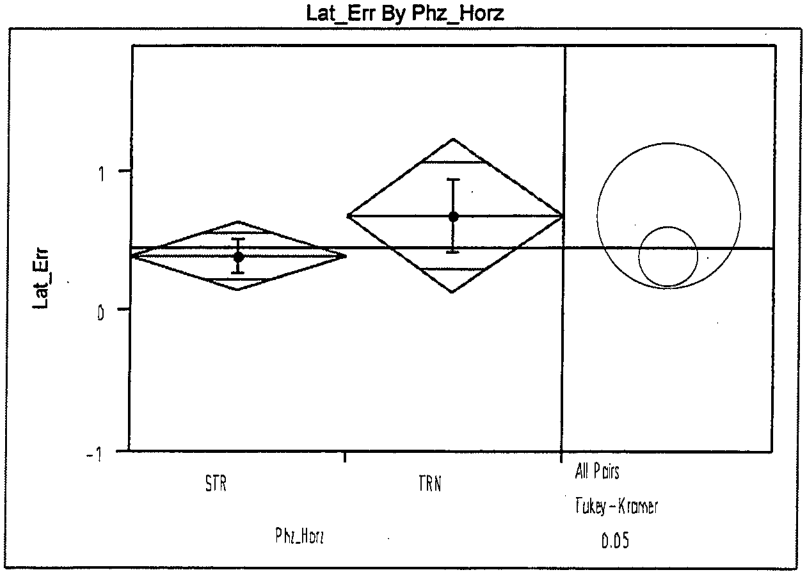
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.0959	1	1619.4	0.7569

t-Test
0.3097

Figure A.2- 109 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5533	0.402110	9.50760	0.12782
TRN	1119	0.716969	8.81856	0.26362

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.314859
STR	-0.31486	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96032

Abs(Dif)-LSD	TRN	STR
TRN	-0.77864	-0.28884
STR	-0.28884	-0.35016

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5533	9.507599	4.986602	4.918904
TRN	1119	8.818562	4.737475	4.624016

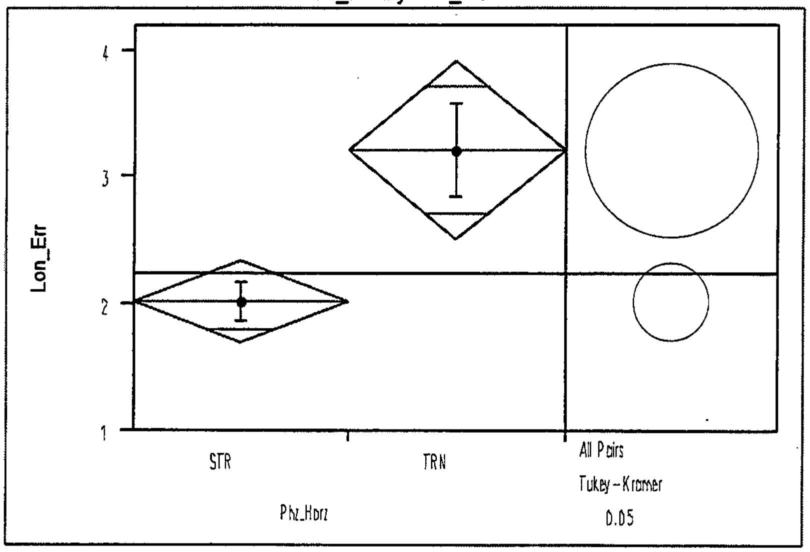
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.1621	1	6650	0.2811
Brown-Forsythe	1.2499	1	6650	0.2636
Levene	0.9054	1	6650	0.3414
Bartlett	10.1778	1	?	0.0014

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.1550	1	1686.6	0.2827
t-Test			
1.0747			

Figure A.2- 110 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5533	2.23391	12.2647	0.16488
TRN	1119	3.41451	12.4332	0.37168

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.00000	1.18061
STR	-1.18061	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96032

Abs(Dif)-LSD	TRN	STR
TRN	-1.01880	0.39071
STR	0.39071	-0.45817

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5533	12.26465	8.110204	8.010440
TRN	1119	12.43317	8.499094	8.308092

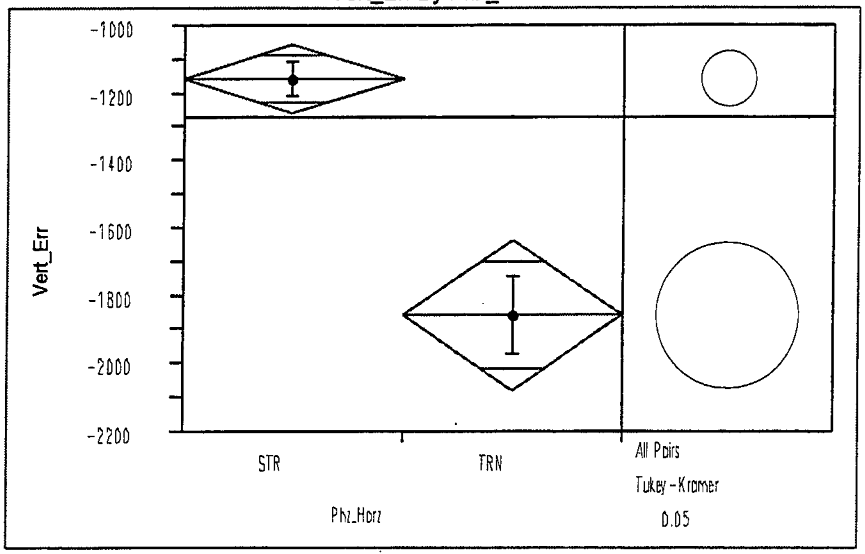
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0995	1	6650	0.7525
Brown-Forsythe	0.9360	1	6650	0.3333
Levene	1.6710	1	6650	0.1962
Bartlett	0.3484	1	?	0.5550

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.4306	1	1588.9	0.0037
t-Test			
2.9035			

Figure A.2- 111 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Vert_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	5533	-1148.82	3830.91	51.50
TRN	1119	-1854.55	4008.78	119.84

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000	705.728
TRN	-705.728	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96032

Abs(Dif)-LSD	STR	TRN
STR	-143.915	457.614
TRN	457.614	-320.015

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	5533	3830.906	2523.343	2077.579
TRN	1119	4008.777	3004.115	2596.993

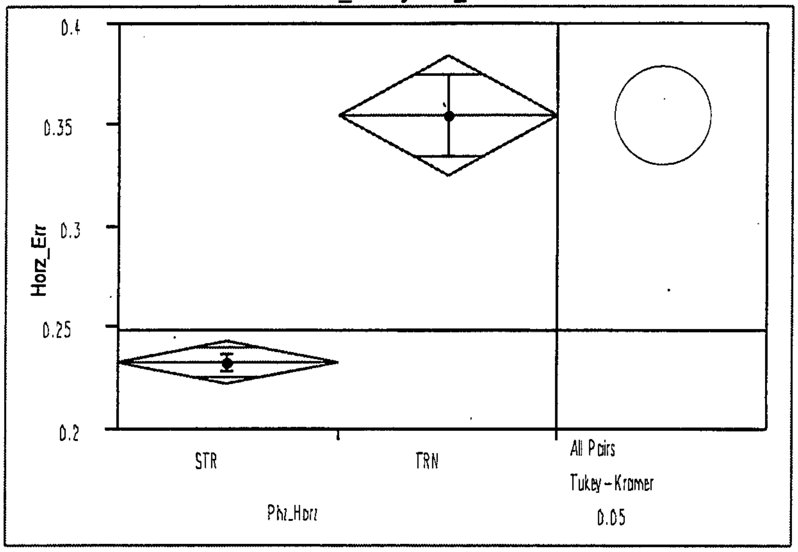
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.9234	1	6650	0.3366
Brown-Forsythe	21.1780	1	6650	<.0001
Levene	26.5802	1	6650	<.0001
Bartlett	3.9075	1	?	0.0481

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
29.2735	1	1558.4	<.0001
t-Test			
5.4105			

Figure A.2- 112 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Horz_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18660	0.234469	0.71145	0.00521
TRN	2505	0.357088	1.00994	0.02018

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.122619
STR	-0.12262	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96008

Abs(Dif)-LSD	TRN	STR
TRN	-0.0417	0.091214
STR	0.091214	-0.01528

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18660	0.711449	0.1940809	0.1629565
TRN	2505	1.009945	0.3193173	0.2706653

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.4391	1	21163	0.2303
Brown-Forsythe	46.7234	1	21163	<.0001
Levene	66.3991	1	21163	<.0001
Bartlett	645.8713	1	?	<.0001

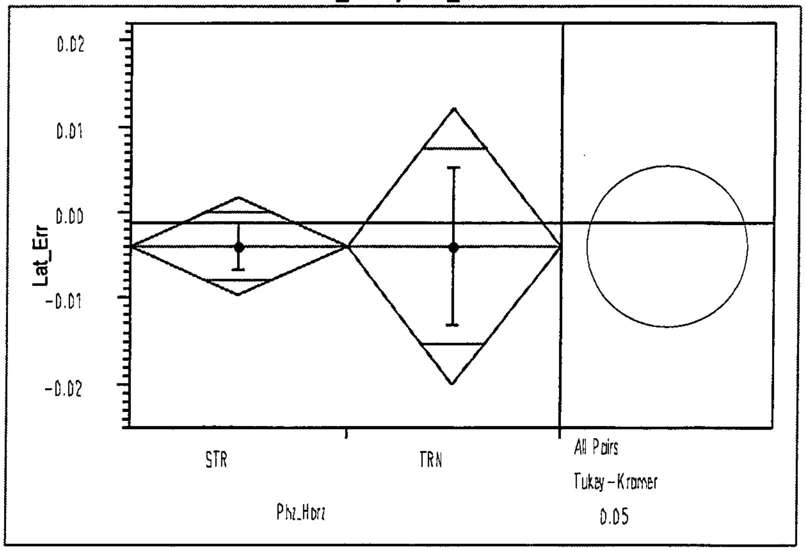
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
34.6191	1	2847	<.0001

t-Test
5.8838

Figure A.2- 113 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18660	-0.00106	0.403764	0.00296
TRN	2505	-0.0024	0.465094	0.00929

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.001338
TRN	-0.00134	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96008

Abs(Dif)-LSD	STR	TRN
STR	-0.00835	-0.01583
TRN	-0.01583	-0.02279

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18660	0.4037643	0.0987145	0.0987052
TRN	2505	0.4650941	0.1861093	0.1859884

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.2594	1	21163	0.6105
Brown-Forsythe	107.4089	1	21163	<.0001
Levene	107.6896	1	21163	<.0001
Bartlett	94.8468	1	?	<.0001

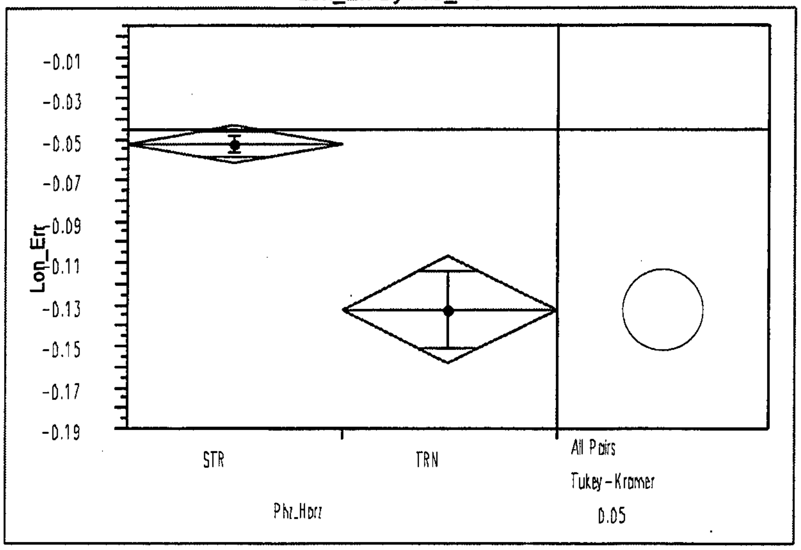
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.0188	1	3032.1	0.8909

t-Test
0.1372

Figure A.2- 114 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18660	-0.03411	0.630039	0.00461
TRN	2505	-0.12295	0.957136	0.01912

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.088839
TRN	-0.08884	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96008

Abs(Dif)-LSD	STR	TRN
STR	-0.01374	0.060601
TRN	0.060601	-0.0375

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18660	0.6300389	0.1795647	0.1794284
TRN	2505	0.9571364	0.2469901	0.2423914

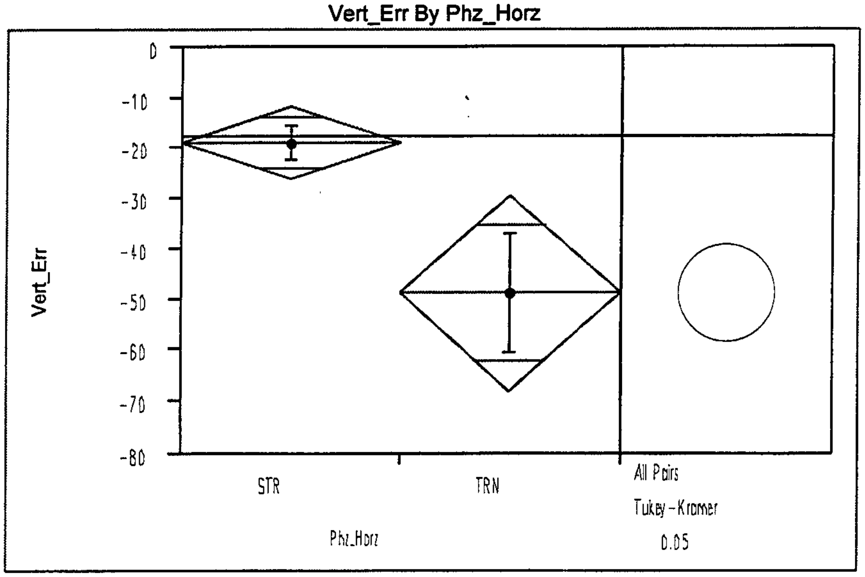
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.7649	1	21163	0.1840
Brown-Forsythe	20.6874	1	21163	<.0001
Levene	23.7514	1	21163	<.0001
Bartlett	950.6784	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
20.3944	1	2802.5	<.0001

t-Test
4.5160

Figure A.2- 115 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	18660	-13.9225	485.830	3.557
TRN	2505	-44.4052	595.086	11.890

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.0000	30.4828
TRN	-30.4828	0.0000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96008

Abs(Dif)-LSD	STR	TRN
STR	-10.1463	9.6284
TRN	9.6284	-27.6922

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	18660	485.8298	78.6304	69.61522
TRN	2505	595.0861	121.1243	93.71964

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.7024	1	21163	0.4020
Brown-Forsythe	5.2355	1	21163	0.0221
Levene	16.4239	1	21163	<.0001
Bartlett	201.2929	1	?	<.0001

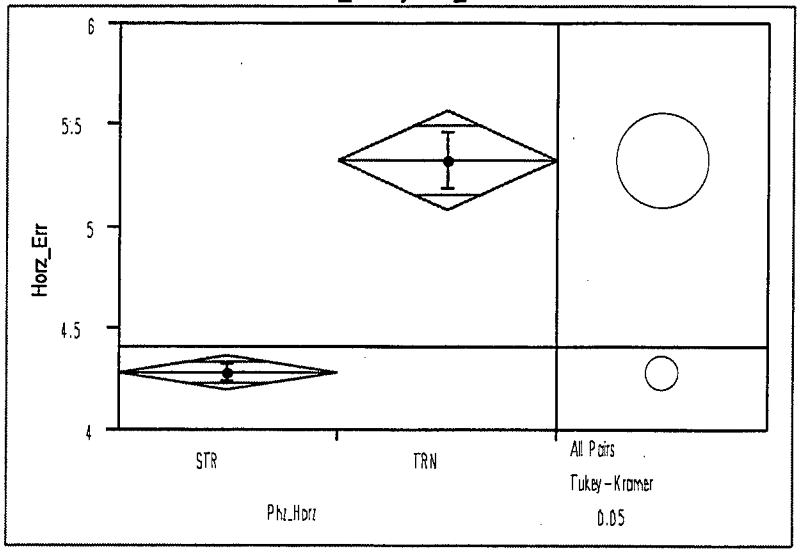
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
6.0331	1	2969	0.0141

t-Test
2.4562

Figure A.2- 116 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	13124	4.29516	5.04140	0.04401
TRN	1657	5.34666	5.91720	0.14536

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.00000	1.05149
STR	-1.05149	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96013

Abs(Dif)-LSD	TRN	STR
TRN	-0.3505	0.788471
STR	0.788471	-0.12454

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	13124	5.041404	3.423732	3.080865
TRN	1657	5.917200	4.169448	3.792364

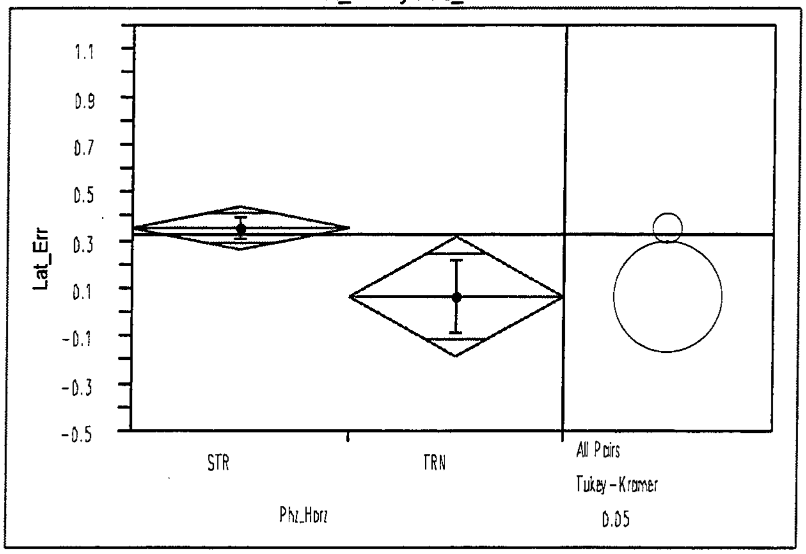
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	13.5501	1	14779	0.0002
Brown-Forsythe	37.9241	1	14779	<.0001
Levene	57.8901	1	14779	<.0001
Bartlett	81.9421	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
47.9314	1	1971.4	<.0001
t-Test			
6.9232			

Figure A.2- 117 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	13124	0.361254	5.21221	0.04550
TRN	1657	0.068356	6.43539	0.15809

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.292898
TRN	-0.2929	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96013

Abs(Dif)-LSD	STR	TRN
STR	-0.12977	0.018828
TRN	0.018828	-0.36522

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	13124	5.212211	2.717162	2.630696
TRN	1657	6.435389	3.473404	3.469688

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	27.5258	1	14779	<.0001
Brown-Forsythe	48.4269	1	14779	<.0001
Levene	40.3462	1	14779	<.0001
Bartlett	145.6606	1	?	<.0001

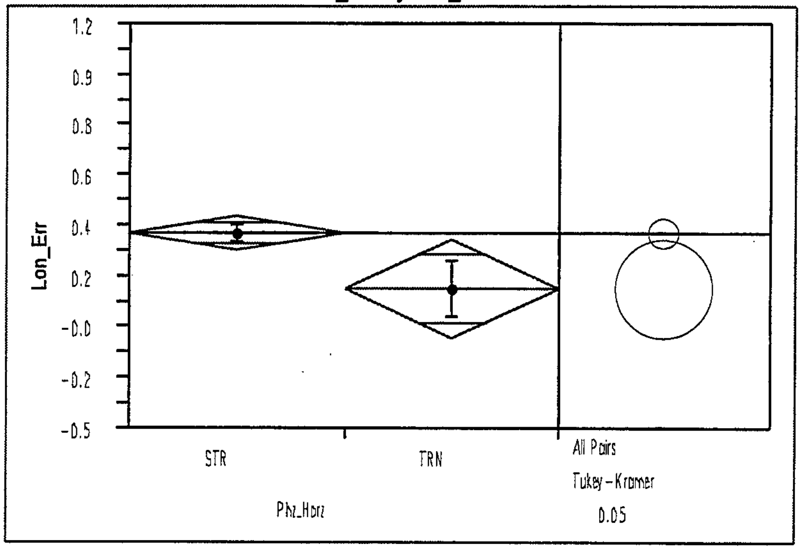
Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.1699	1	1940	0.0752

t-Test
1.7804

Figure A.2- 118 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	13124	0.343574	4.05584	0.03540
TRN	1657	0.104021	4.71036	0.11572

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.239553
TRN	-0.23955	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96013

Abs(Dif)-LSD	STR	TRN
STR	-0.10004	0.028278
TRN	0.028278	-0.28154

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	13124	4.055844	2.536440	2.530586
TRN	1657	4.710364	3.074113	3.073069

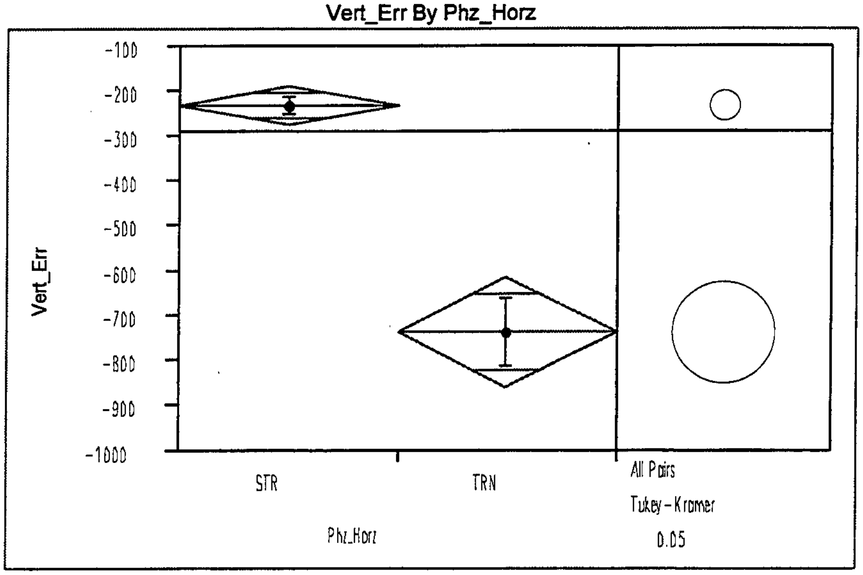
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	11.0260	1	14779	0.0009
Brown-Forsythe	41.7386	1	14779	<.0001
Levene	41.2130	1	14779	<.0001
Bartlett	71.0945	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.9188	1	1978.4	0.0479

t-Test
1.9796

Figure A.2- 119 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	13124	-228.206	2515.82	21.961
TRN	1657	-739.485	3128.62	76.859

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000	511.279
TRN	-511.279	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96013

Abs(Dif)-LSD	STR	TRN
STR	-62.712	378.837
TRN	378.837	-176.491

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	13124	2515.824	1238.933	1107.942
TRN	1657	3128.625	2023.243	1743.558

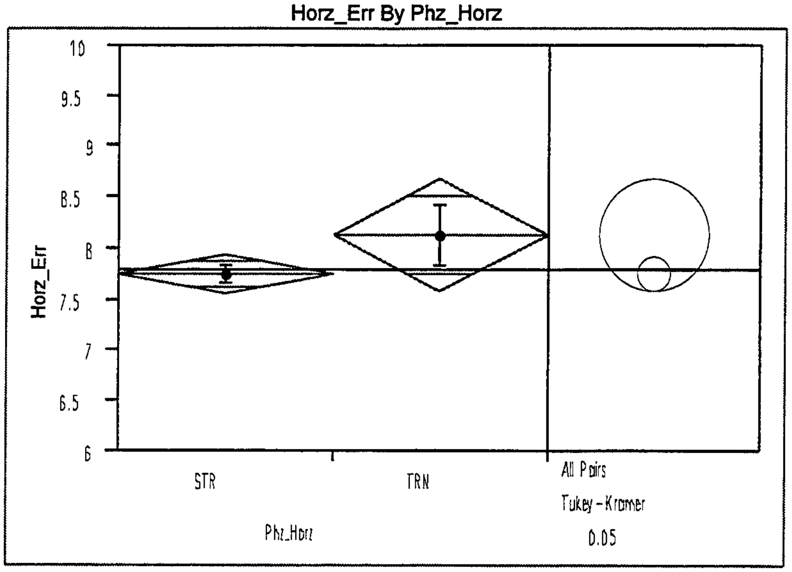
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	24.2333	1	14779	<.0001
Brown-Forsythe	110.2038	1	14779	<.0001
Levene	184.8905	1	14779	<.0001
Bartlett	156.3317	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
40.9118	1	1935.8	<.0001

t-Test
6.3962

Figure A.2- 120 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	7275	7.75291	8.35611	0.09797
TRN	899	8.12008	9.02906	0.30114

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.367168
STR	-0.36717	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96026

Abs(Dif)-LSD	TRN	STR
TRN	-0.77968	-0.21722
STR	-0.21722	-0.27408

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	7275	8.356110	5.935296	5.441148
TRN	899	9.029061	6.335328	5.798658

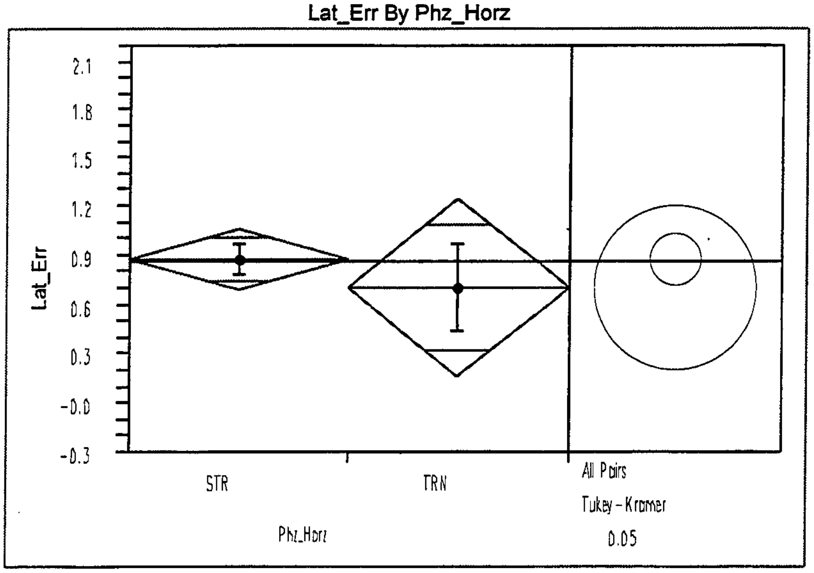
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.9409	1	8172	0.1636
Brown-Forsythe	2.0633	1	8172	0.1509
Levene	3.6237	1	8172	0.0570
Bartlett	9.9813	1	?	0.0016

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.3443	1	1096.6	0.2465

t-Test
1.1595

Figure A.2- 121 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	7275	0.883040	8.26596	0.09691
TRN	899	0.707953	8.16178	0.27221

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.175086
TRN	-0.17509	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96026

Abs(Dif)-LSD	STR	TRN
STR	-0.26829	-0.39696
TRN	-0.39696	-0.76321

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	7275	8.265958	4.502071	4.253076
TRN	899	8.161776	4.561810	4.429300

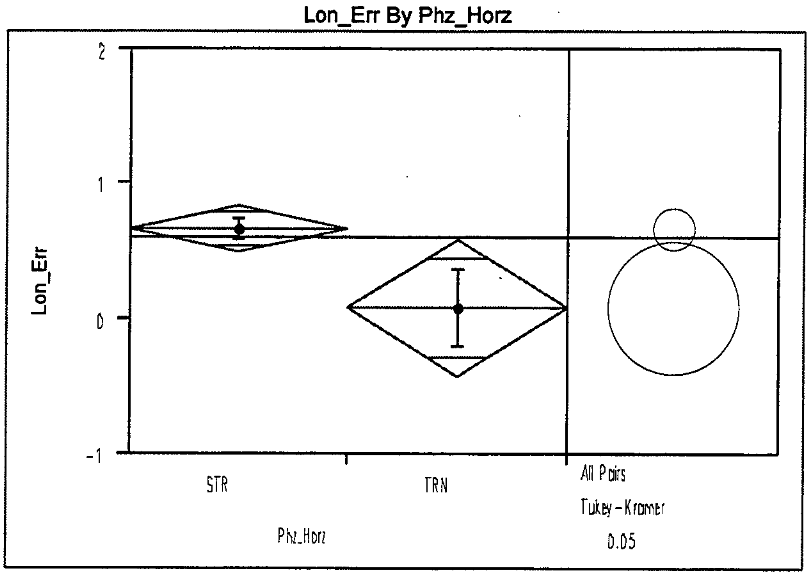
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0381	1	8172	0.8452
Brown-Forsythe	0.4910	1	8172	0.4835
Levene	0.0597	1	8172	0.8069
Bartlett	0.2554	1	?	0.6133

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.3672	1	1137.8	0.5447

t-Test
0.6059

Figure A.2- 122 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	7275	0.771716	7.76137	0.09100
TRN	899	0.207019	8.96514	0.29900

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.564697
TRN	-0.5647	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96026

Abs(Dif)-LSD	STR	TRN
STR	-0.25685	0.017044
TRN	0.017044	-0.73067

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	7275	7.761372	5.020612	5.006082
TRN	899	8.965141	5.380877	5.367271

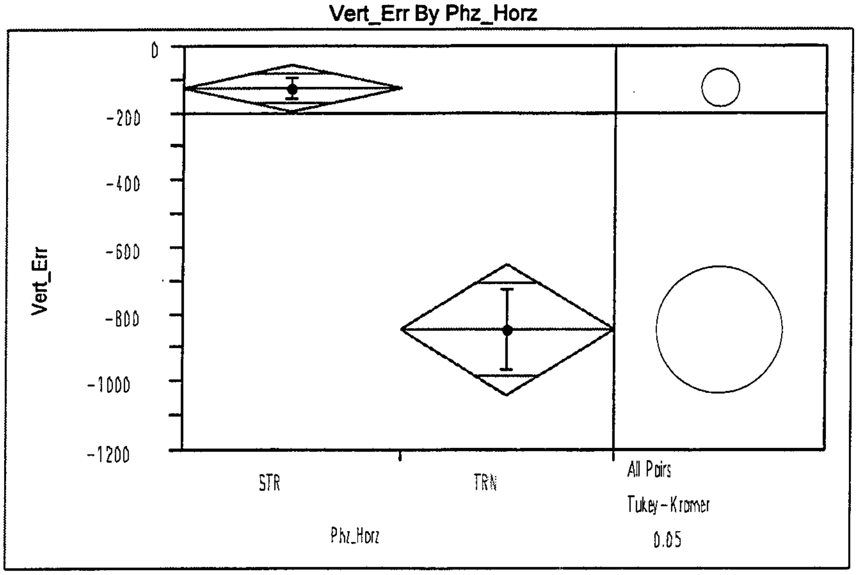
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	7.4284	1	8172	0.0064
Brown-Forsythe	2.8110	1	8172	0.0937
Levene	2.8199	1	8172	0.0931
Bartlett	35.8064	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.2644	1	1070.9	0.0711

t-Test
1.8068

Figure A.2- 123 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	7275	-123.003	2955.87	34.66
TRN	899	-837.674	3769.17	125.71

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000	714.671
TRN	-714.671	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96026

Abs(Dif)-LSD	STR	TRN
STR	-99.321	502.901
TRN	502.901	-282.540

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	7275	2955.871	1329.427	1257.581
TRN	899	3769.167	2394.261	2063.472

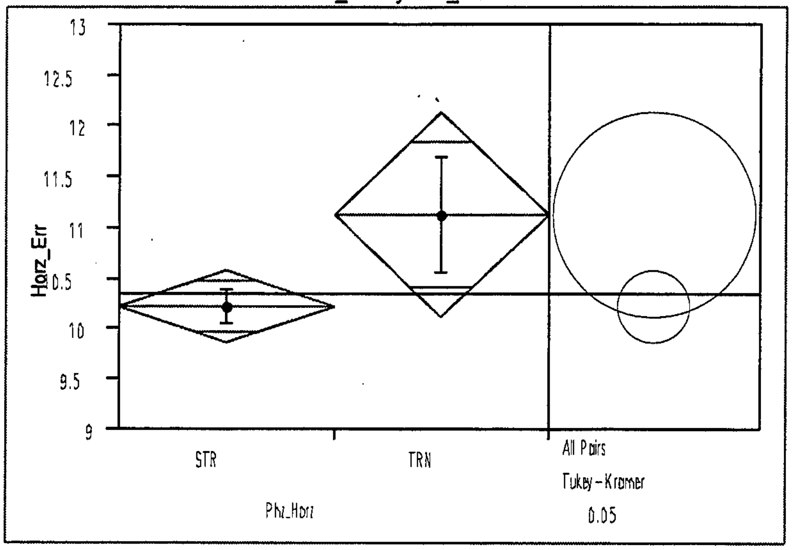
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	15.8051	1	8172	<.0001
Brown-Forsythe	68.8047	1	8172	<.0001
Levene	127.1680	1	8172	<.0001
Bartlett	107.0770	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
30.0379	1	1038.9	<.0001
t-Test			
5.4807			

Figure A.2- 124 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_Horz



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	3466	10.2454	10.9529	0.18604
TRN	446	11.1468	12.0732	0.57168

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.901409
STR	-0.90141	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96057

Abs(Dif)-LSD	TRN	STR
TRN	-1.45550	-0.19200
STR	-0.19200	-0.52211

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	3466	10.95292	7.759011	7.125747
TRN	446	12.07322	8.742910	7.778772

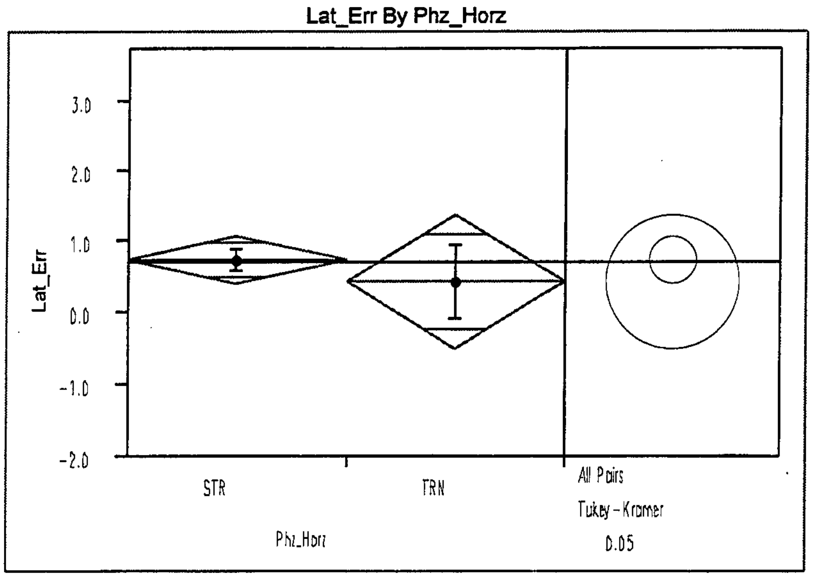
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.8495	1	3910	0.1739
Brown-Forsythe	1.9751	1	3910	0.1600
Levene	6.2898	1	3910	0.0122
Bartlett	7.8580	1	?	0.0051

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.2481	1	543.46	0.1344

t-Test
1.4994

Figure A.2- 125 Statistical Tests for Horizontal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	3466	0.739511	10.2167	0.17354
TRN	446	0.463890	11.2007	0.53037

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000000	0.275622
TRN	-0.27562	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96057

Abs(Dif)-LSD	STR	TRN
STR	-0.48666	-0.74355
TRN	-0.74355	-1.35667

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	3466	10.21674	5.356596	5.161818
TRN	446	11.20066	5.935987	5.873975

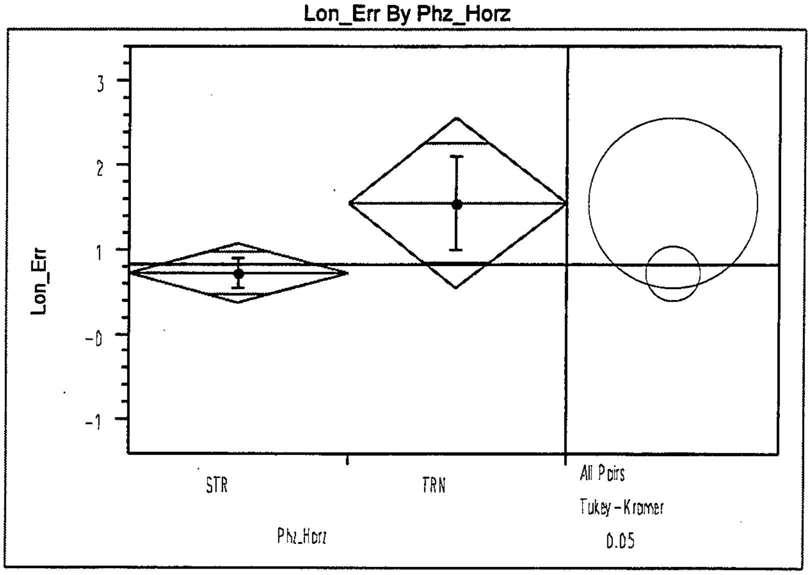
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.9586	1	3910	0.3276
Brown-Forsythe	2.5132	1	3910	0.1130
Levene	1.7155	1	3910	0.1904
Bartlett	6.9853	1	?	0.0082

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.2440	1	544.59	0.6216

t-Test
0.4939

Figure A.2- 126 Statistical Tests for Lateral Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	3466	0.75035	10.9303	0.18566
TRN	446	1.57443	11.9222	0.56453

Means Comparisons

Dif=Mean[i]-Mean[j]	TRN	STR
TRN	0.000000	0.824080
STR	-0.82408	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96057

Abs(Dif)-LSD	TRN	STR
TRN	-1.45045	-0.26553
STR	-0.26553	-0.52030

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

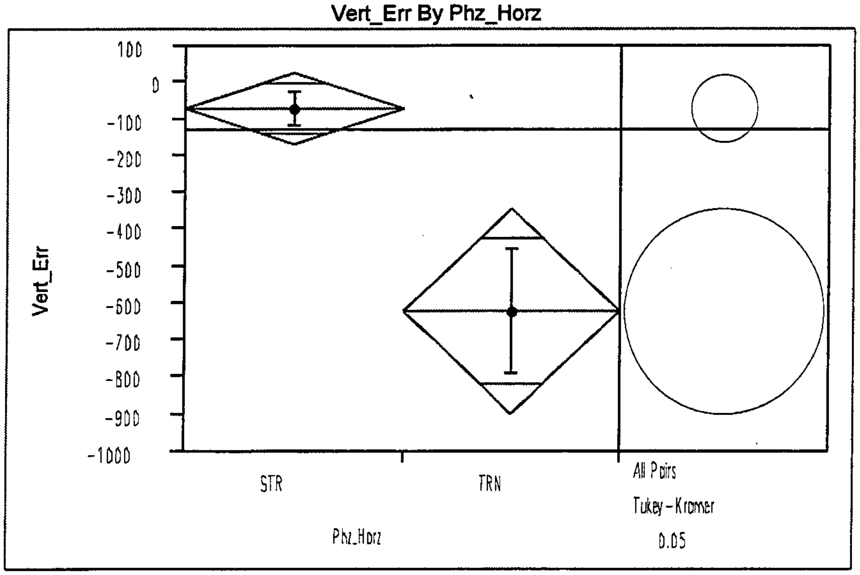
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	3466	10.93034	7.020180	7.000370
TRN	446	11.92215	7.567985	7.456522

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.6369	1	3910	0.2008
Brown-Forsythe	1.1306	1	3910	0.2877
Levene	1.6508	1	3910	0.1989
Bartlett	6.2172	1	?	0.0127

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.9229	1	545.65	0.1661
t-Test			
1.3867			

Figure A.2- 127 Statistical Tests for Longitudinal Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
STR	3466	-65.790	2982.05	50.65
TRN	446	-620.819	3577.84	169.42

Means Comparisons

Dif=Mean[i]-Mean[j]	STR	TRN
STR	0.000	555.030
TRN	-555.030	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 1.96057

Abs(Dif)-LSD	STR	TRN
STR	-143.912	253.650
TRN	253.650	-401.185

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
STR	3466	2982.054	1330.937	1291.321
TRN	446	3577.840	2211.662	1900.279

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.8857	1	3910	0.0271
Brown-Forsythe	19.5504	1	3910	<.0001
Levene	42.5162	1	3910	<.0001
Bartlett	28.7096	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
9.8524	1	527.57	0.0018
t-Test			
3.1389			

Figure A.2- 128 Statistical Tests for Vertical Error and Horizontal Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

A.2.4 Vertical Phase of Flight Per Look Ahead Time

A.2.4.1 Summary Tables

Look Ahead Time	0			300		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	25326	4026	3257	21663	2333	3167
Avg. Horz. Error	0.25	0.37	0.36	2.41	3.9	3.3
Stddev. Horz. Error	0.79	1.14	0.83	3.04	3.68	3.5
Max. Horz. Error	48.02	29.51	17.72	88.45	46.09	33.42
Min. Horz. Error	0	0	0	0	0.04	0.02
Avg. Lat. Error	0	0.01	0.01	0.04	0.04	-0.09
Stddev. Lat. Error	0.37	0.72	0.58	3.08	4.19	3.98
Max. Lat. Error	18.66	22.88	8.7	46.61	30.93	26.79
Min. Lat. Error	-15.1	-11.26	-15.57	-46.12	-25.39	-22.91
Avg. Abs. Lat. Error	0.11	0.17	0.19	1.57	2.44	2.32
Stddev. Abs. Lat. Error	0.36	0.7	0.55	2.65	3.4	3.23
Max. Abs. Lat. Error	18.66	22.88	15.57	46.61	30.93	26.79
Min. Abs. Lat. Error	0	0	0	0	0	0
Avg. Long. Error	-0.04	-0.04	-0.12	-0.11	0.49	-0.08
Stddev. Long. Error	0.74	0.95	0.68	2.36	3.31	2.69
Max. Long. Error	47.54	18.64	4.09	22.74	46.01	14.86
Min. Long. Error	-31.16	-23.09	-15	-87.99	-18.82	-33.04
Avg. Abs. Long. Error	0.19	0.29	0.26	1.35	2.37	1.73
Stddev. Abs. Long. Error	0.72	0.91	0.64	1.94	2.36	2.06
Max. Abs. Long. Error	47.54	23.09	15	87.99	46.01	33.04
Min. Abs. Long. Error	0	0	0	0	0	0
Avg. Vert. Error	-65.84	-125.87	-321.83	-266.39	-499.48	-2337.55
Stddev. Vert. Error	566.14	1473.62	1001.71	1697.76	3286.46	2933.07
Max. Vert. Error	17000	18889	5261.11	26788.2	27290	9495.55
Min. Vert. Error	-15565.9	-31466.5	-16406.8	-18228	-24677	-17950
Avg. Abs. Vert. Error	103.29	299.9	367.97	652.46	2379.7	2889.35
Stddev. Abs. Vert. Error	560.52	1448.25	985.69	1589.85	2320.56	2391.19
Max. Abs. Vert. Error	17000	31466.46	16406.83	26788.2	27290	17950
Min. Abs. Vert. Error	0	0	0	0	0	0
Avg. Slant Range Error	0.25	0.38	0.37	2.42	3.95	3.39
Stddev. Slant Range Error	0.8	1.16	0.84	3.04	3.67	3.46
Max. Slant Range Error	48.03	29.51	17.73	88.56	46.09	33.42
Min. Slant Range Error	0	0	0	0.01	0.09	0.06

Figure A.2- 129 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	600			900		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	18016	1014	2878	14314	304	2323
Avg. Horz. Error	4.33	6.92	4.91	6.13	9.87	6.23
Stddev. Horz. Error	4.9	5.81	4.71	6.57	8.49	6.05
Max. Horz. Error	65.69	40.91	67.08	86.49	56.6	101.09
Min. Horz. Error	0.01	0.06	0.02	0.01	0.13	0.02
Avg. Lat. Error	0.29	0.45	-0.18	0.54	1.99	-0.2
Stddev. Lat. Error	4.9	6.74	5.13	6.34	10	5.58
Max. Lat. Error	55.5	38.94	33.84	60.84	54.78	31.18
Min. Lat. Error	-38.27	-33.24	-34.23	-43.96	-34.75	-64.27
Avg. Abs. Lat. Error	2.54	3.6	3.03	3.29	5.54	3.3
Stddev. Abs. Lat. Error	4.2	5.71	4.14	5.44	8.56	4.5
Max. Abs. Lat. Error	55.5	38.94	34.23	60.84	54.78	64.27
Min. Abs. Lat. Error	0	0	0	0	0	0
Avg. Long. Error	0.17	2.04	0.45	0.57	1.51	0.98
Stddev. Long. Error	4.32	5.66	4.45	6.32	7.97	6.58
Max. Long. Error	54.4	19.77	59.63	58.31	25.7	41.14
Min. Long. Error	-59.56	-29.72	-25.16	-83.04	-36.79	-78.02
Avg. Abs. Long. Error	2.69	4.72	3.02	4.06	6.29	4.32
Stddev. Abs. Long. Error	3.39	3.72	3.3	4.88	5.11	5.06
Max. Abs. Long. Error	59.56	29.72	59.63	83.04	36.79	78.02
Min. Abs. Long. Error	0	0.01	0	0	0	0
Avg. Vert. Error	-335.38	-539.09	-3494.58	-424.39	-189.58	-4017.92
Stddev. Vert. Error	2323.44	4371.02	3530.09	2859.83	4704.35	4223.02
Max. Vert. Error	28990	25190	10649	29003	28017	24098
Min. Vert. Error	-21075.3	-14510	-26868	-21566	-9900	-32426
Avg. Abs. Vert. Error	1030.99	3176.39	3873.94	1317.35	3121.12	4494.61
Stddev. Abs. Vert. Error	2108.99	3049.15	3108.89	2573.56	3520.43	3711.37
Max. Abs. Vert. Error	28990	25190	26868	29003	28017	32426
Min. Abs. Vert. Error	0	1	0	0	14	0.37
Avg. Slant Range Error	4.35	6.97	5.03	6.15	9.91	6.35
Stddev. Slant Range Error	4.9	5.8	4.67	6.57	8.47	6
Max. Slant Range Error	65.69	40.91	67.09	86.49	56.6	101.09
Min. Slant Range Error	0.01	0.2	0.11	0.01	0.69	0.13

Figure A.2- 130 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1200			1500		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	10969	97	1855	7967	39	1255
Avg. Horz. Error	7.81	12.2	7.67	9.48	13.87	8.75
Stddev. Horz. Error	8.11	9.5	8	9.8	9.12	9.43
Max. Horz. Error	103.04	40.57	86.73	87.22	32.25	94.14
Min. Horz. Error	0.01	0.22	0.02	0.03	0.46	0.13
Avg. Lat. Error	0.69	2.7	-0.29	0.59	2.89	-0.42
Stddev. Lat. Error	7.61	11.59	6.08	8.79	11.28	6.6
Max. Lat. Error	76.1	39.99	39.35	85.67	31.6	32.52
Min. Lat. Error	-55.56	-30.13	-44.51	-65.63	-22.26	-55.21
Avg. Abs. Lat. Error	3.94	6.67	3.6	4.48	7.33	3.93
Stddev. Abs. Lat. Error	6.54	9.84	4.91	7.59	8.98	5.32
Max. Abs. Lat. Error	76.1	39.99	44.51	85.67	31.6	55.21
Min. Abs. Lat. Error	0	0.01	0	0	0.03	0
Avg. Long. Error	1.09	2.75	1.75	1.72	4.99	2.64
Stddev. Long. Error	8.2	9.55	9.09	10.26	10.91	10.72
Max. Long. Error	53.21	26.71	77.59	86.1	25.91	94.14
Min. Long. Error	-94.35	-20.53	-85.87	-64.82	-16.12	-73.71
Avg. Abs. Long. Error	5.4	7.87	5.69	6.8	9.71	6.67
Stddev. Abs. Long. Error	6.27	6.03	7.31	7.88	6.92	8.79
Max. Abs. Long. Error	94.35	26.71	85.87	86.1	25.91	94.14
Min. Abs. Long. Error	0	0.09	0	0	0.12	0
Avg. Vert. Error	-536.07	-380.64	-4145.37	-653.47	332.41	-4355.58
Stddev. Vert. Error	3091.44	3302.06	4589.18	3216.44	2442.86	4808.4
Max. Vert. Error	29003	15050	28590	29003	5086	13797
Min. Vert. Error	-26558	-6427.62	-28868	-22800	-5981	-27901
Avg. Abs. Vert. Error	1459.99	2476.87	4756.35	1565.95	1992.82	4964.09
Stddev. Abs. Vert. Error	2777.16	2202.54	3952.07	2884.45	1416.02	4176.73
Max. Abs. Vert. Error	29003	15050	28868	29003	5981	27901
Min. Abs. Vert. Error	0	5	0	0	112	4.4
Avg. Slant Range Error	7.83	12.23	7.79	9.51	13.88	8.87
Stddev. Slant Range Error	8.1	9.48	7.95	9.79	9.11	9.38
Max. Slant Range Error	103.05	40.57	86.86	87.23	32.25	94.14
Min. Slant Range Error	0.01	0.8	0.19	0.03	0.52	0.22

Figure A.2- 131 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	1800					
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	5745	13	899			
Avg. Horz. Error	11.07	18.41	10.01			
Stddev. Horz. Error	11.37	10.83	10.11			
Max. Horz. Error	96.9	37.99	98.82			
Min. Horz. Error	0.03	3.5	0.11			
Avg. Lat. Error	0.6	8.51	-0.59			
Stddev. Lat. Error	9.59	13.95	7.83			
Max. Lat. Error	86.54	27.63	26.02			
Min. Lat. Error	-62.21	-19.27	-59.89			
Avg. Abs. Lat. Error	4.9	12.19	4.56			
Stddev. Abs. Lat. Error	8.26	10.59	6.4			
Max. Abs. Lat. Error	86.54	27.63	59.89			
Min. Abs. Lat. Error	0	0.01	0			
Avg. Long. Error	2.3	1.44	3.24			
Stddev. Long. Error	12.42	14.47	11.41			
Max. Long. Error	96.86	18.76	59.82			
Min. Long. Error	-77.43	-26.07	-78.6			
Avg. Abs. Long. Error	8.2	11.51	7.65			
Stddev. Abs. Long. Error	9.62	8.25	9.07			
Max. Abs. Long. Error	96.86	26.07	78.6			
Min. Abs. Long. Error	0	0.16	0			
Avg. Vert. Error	-741.01	1569.38	-4666.23			
Stddev. Vert. Error	3391.9	2217.34	4881.61			
Max. Vert. Error	29003	5896	6933			
Min. Vert. Error	-24600	-2690	-29635			
Avg. Abs. Vert. Error	1698.16	2148.15	5136.5			
Stddev. Abs. Vert. Error	3028.19	1608.01	4383.5			
Max. Abs. Vert. Error	29003	5896	29635			
Min. Abs. Vert. Error	0	532	0			
Avg. Slant Range Error	11.09	18.42	10.12			
Stddev. Slant Range Error	11.36	10.82	10.06			
Max. Slant Range Error	96.91	37.99	98.82			
Min. Slant Range Error	0.03	3.56	0.27			

Figure A.2- 132 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at All Altitudes

Look Ahead Time	0			300		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	17187	2208	1814	14807	1911	1733
Avg. Horz. Error	0.22	0.42	0.31	2.26	3.76	3.2
Stddev. Horz. Error	0.64	1.34	0.69	3.16	3.66	3.75
Max. Horz. Error	48.02	29.51	17.72	88.45	46.09	27.72
Min. Horz. Error	0	0	0	0	0.04	0.02
Avg. Lat. Error	0	0.03	-0.01	0.08	0.15	-0.22
Stddev. Lat. Error	0.29	0.84	0.55	3.22	4.16	4.41
Max. Lat. Error	13.61	22.88	8.7	46.61	30.93	26.79
Min. Lat. Error	-6.81	-10.95	-15.57	-46.12	-22.33	-22.91
Avg. Abs. Lat. Error	0.09	0.19	0.16	1.53	2.36	2.49
Stddev. Abs. Lat. Error	0.28	0.82	0.52	2.83	3.43	3.64
Max. Abs. Lat. Error	13.61	22.88	15.57	46.61	30.93	26.79
Min. Abs. Lat. Error	0	0	0	0	0	0
Avg. Long. Error	-0.04	-0.01	-0.09	-0.06	0.94	-0.05
Stddev. Long. Error	0.61	1.13	0.51	2.16	3.06	2.2
Max. Long. Error	47.54	18.64	3.56	22.18	46.01	14.86
Min. Long. Error	-31.16	-23.09	-10.07	-87.99	-16.2	-14.59
Avg. Abs. Long. Error	0.17	0.33	0.22	1.18	2.27	1.42
Stddev. Abs. Long. Error	0.59	1.08	0.47	1.81	2.25	1.69
Max. Abs. Long. Error	47.54	23.09	10.07	87.99	46.01	14.86
Min. Abs. Long. Error	0	0	0	0	0	0
Avg. Vert. Error	2.79	-23.34	-202.07	53.33	-109.4	-1861.93
Stddev. Vert. Error	262.98	1122.12	832.64	1205.18	2889.78	2960.92
Max. Vert. Error	17000	18889	5261.11	26788.2	27290	9495.55
Min. Vert. Error	-11767	-21500	-16406.8	-18228	-10819.2	-17950
Avg. Abs. Vert. Error	30.82	250.36	249.73	340.67	2048.96	2653.41
Stddev. Abs. Vert. Error	261.19	1094.07	819.6	1157.26	2040.2	2278.41
Max. Abs. Vert. Error	17000	21500	16406.83	26788.2	27290	17950
Min. Abs. Vert. Error	0	0	0	0	0	0
Avg. Slant Range Error	0.22	0.43	0.31	2.27	3.81	3.3
Stddev. Slant Range Error	0.64	1.35	0.7	3.16	3.65	3.72
Max. Slant Range Error	48.03	29.51	17.73	88.56	46.09	27.72
Min. Slant Range Error	0	0	0	0.01	0.09	0.06

Figure A.2- 133 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	600			900		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	12322	945	1540	9768	289	1160
Avg. Horz. Error	4.16	6.99	4.82	6.05	9.94	5.79
Stddev. Horz. Error	5.02	5.93	5.21	6.8	8.59	5.61
Max. Horz. Error	57.5	40.91	67.08	75.25	56.6	43.7
Min. Horz. Error	0.01	0.06	0.02	0.01	0.13	0.06
Avg. Lat. Error	0.4	0.63	-0.42	0.76	2.04	-0.44
Stddev. Lat. Error	5.17	6.84	5.77	6.88	10.17	5.87
Max. Lat. Error	55.5	38.94	33.84	60.84	54.78	31.18
Min. Lat. Error	-38.27	-33.24	-34.23	-43.96	-34.75	-35.37
Avg. Abs. Lat. Error	2.57	3.61	3.38	3.48	5.66	3.5
Stddev. Abs. Lat. Error	4.5	5.84	4.7	5.98	8.69	4.74
Max. Abs. Lat. Error	55.5	38.94	34.23	60.84	54.78	35.37
Min. Abs. Lat. Error	0	0	0	0	0	0
Avg. Long. Error	0.17	2.35	0.2	0.4	1.84	0.37
Stddev. Long. Error	3.96	5.61	4.11	5.89	7.87	5.5
Max. Long. Error	54.4	19.77	59.63	58.31	25.7	41.14
Min. Long. Error	-28	-29.72	-21.01	-61.99	-36.79	-21.74
Avg. Abs. Long. Error	2.44	4.77	2.56	3.75	6.28	3.58
Stddev. Abs. Long. Error	3.13	3.77	3.23	4.57	5.08	4.19
Max. Abs. Long. Error	54.4	29.72	59.63	61.99	36.79	41.14
Min. Abs. Long. Error	0	0.03	0	0	0	0
Avg. Vert. Error	65.83	-380.28	-3032.69	98.92	-84.47	-3397.46
Stddev. Vert. Error	2040.95	4319.61	3379.09	2565.73	4762.72	4004.29
Max. Vert. Error	28990	25190	10649	29003	28017	24098
Min. Vert. Error	-13004	-14510	-16708	-17000	-9900	-20550
Avg. Abs. Vert. Error	736.19	3083.65	3537.88	972.68	3135.07	4068.74
Stddev. Abs. Vert. Error	1904.67	3047.09	2845.48	2376.24	3581.59	3319.36
Max. Abs. Vert. Error	28990	25190	16708	29003	28017	24098
Min. Abs. Vert. Error	0	1	0	0	14	13.63
Avg. Slant Range Error	4.18	7.04	4.93	6.07	9.99	5.9
Stddev. Slant Range Error	5.02	5.92	5.17	6.79	8.57	5.56
Max. Slant Range Error	57.5	40.91	67.09	75.4	56.6	43.71
Min. Slant Range Error	0.01	0.2	0.11	0.01	0.69	0.13

Figure A.2- 134 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	1200			1500		
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	7238	95	856	5111	36	558
Avg. Horz. Error	7.78	12.32	7.42	9.22	13.88	8
Stddev. Horz. Error	8.38	9.55	8.56	10.02	9.28	7.69
Max. Horz. Error	78.4	40.57	86.73	87.22	32.25	64.14
Min. Horz. Error	0.01	0.22	0.02	0.03	0.46	0.13
Avg. Lat. Error	1	2.79	-0.51	0.93	3.19	-0.88
Stddev. Lat. Error	8.35	11.69	6.58	9.7	11.66	6.9
Max. Lat. Error	76.1	39.99	39.35	85.67	31.6	21.76
Min. Lat. Error	-55.56	-30.13	-36.62	-65.63	-22.26	-41.85
Avg. Abs. Lat. Error	4.28	6.77	3.89	4.87	7.71	4.24
Stddev. Abs. Lat. Error	7.24	9.92	5.33	8.44	9.24	5.52
Max. Abs. Lat. Error	76.1	39.99	39.35	85.67	31.6	41.85
Min. Abs. Lat. Error	0	0.01	0	0	0.03	0
Avg. Long. Error	0.66	2.72	0.81	0.8	4.3	0.64
Stddev. Long. Error	7.71	9.62	9.17	9.49	10.89	8.62
Max. Long. Error	53.21	26.71	77.59	61.01	25.91	63.91
Min. Long. Error	-48.76	-20.53	-85.87	-61.99	-16.12	-32.01
Avg. Abs. Long. Error	5.01	7.91	5.14	6.13	9.41	5.53
Stddev. Abs. Long. Error	5.9	6.05	7.64	7.29	6.83	6.65
Max. Abs. Long. Error	53.21	26.71	85.87	61.99	25.91	63.91
Min. Abs. Long. Error	0	0.09	0.01	0	0.12	0
Avg. Vert. Error	187.11	-408.74	-3460.7	160.58	433.06	-3346.38
Stddev. Vert. Error	2586.64	3331.19	4468.07	2589.52	2245.76	4315.48
Max. Vert. Error	29003	15050	28590	29003	5086	13797
Min. Vert. Error	-16883	-6427.62	-19633	-17000	-3589	-20550
Avg. Abs. Vert. Error	972.97	2508.94	4350.88	997.14	1893.33	4259.77
Stddev. Abs. Vert. Error	2403.93	2214.49	3605.79	2395.19	1244.66	3415.18
Max. Abs. Vert. Error	29003	15050	28590	29003	5086	20550
Min. Abs. Vert. Error	0	5	0	0	183	4.4
Avg. Slant Range Error	7.79	12.34	7.54	9.24	13.89	8.09
Stddev. Slant Range Error	8.38	9.54	8.51	10.02	9.26	7.65
Max. Slant Range Error	78.4	40.57	86.86	87.23	32.25	64.17
Min. Slant Range Error	0.01	0.8	0.21	0.03	0.52	0.22

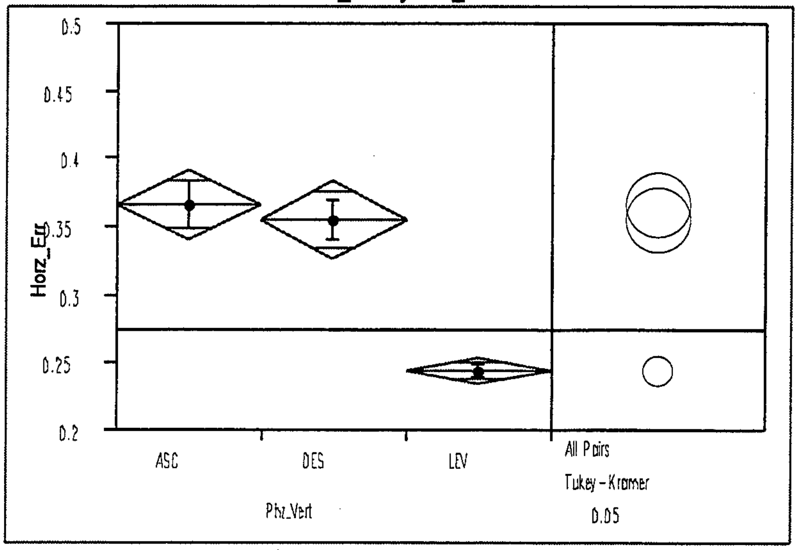
Figure A.2- 135 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

Look Ahead Time	1800					
Vertical Phase of Flight	Level	Ascent	Descent	Level	Ascent	Descent
Sample Quantity	3512	13	392			
Avg. Horz. Error	10.51	18.41	8.56			
Stddev. Horz. Error	11.37	10.83	7.71			
Max. Horz. Error	87.65	37.99	51.25			
Min. Horz. Error	0.03	3.5	0.11			
Avg. Lat. Error	0.91	8.51	-1.33			
Stddev. Lat. Error	10.49	13.95	8.21			
Max. Lat. Error	86.54	27.63	20.43			
Min. Lat. Error	-62.21	-19.27	-51.14			
Avg. Abs. Lat. Error	5.25	12.19	4.93			
Stddev. Abs. Lat. Error	9.13	10.59	6.7			
Max. Abs. Lat. Error	86.54	27.63	51.14			
Min. Abs. Lat. Error	0	0.01	0			
Avg. Long. Error	0.79	1.44	1.22			
Stddev. Long. Error	11.33	14.47	7.88			
Max. Long. Error	77.47	18.76	37.81			
Min. Long. Error	-58.65	-26.07	-23.84			
Avg. Abs. Long. Error	7.19	11.51	5.66			
Stddev. Abs. Long. Error	8.79	8.25	5.62			
Max. Abs. Long. Error	77.47	26.07	37.81			
Min. Abs. Long. Error	0	0.16	0			
Avg. Vert. Error	268.41	1569.38	-3744.79			
Stddev. Vert. Error	2605.18	2217.34	4239.04			
Max. Vert. Error	29003	5896	6933			
Min. Vert. Error	-16883	-2690	-17851			
Avg. Abs. Vert. Error	1009.74	2148.15	4462.2			
Stddev. Abs. Vert. Error	2416.44	1608.01	3473.71			
Max. Abs. Vert. Error	29003	5896	17851			
Min. Abs. Vert. Error	0	532	0			
Avg. Slant Range Error	10.53	18.42	8.65			
Stddev. Slant Range Error	11.37	10.82	7.67			
Max. Slant Range Error	87.65	37.99	51.27			
Min. Slant Range Error	0.03	3.56	0.27			

Figure A.2- 136 Descriptive Statistics for Vertical Phase of Flight per Look Ahead Time for Samples at Altitudes Above 18,000 Feet

A.2.4.2 Statistical Tests

Horz_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4019	0.370118	1.13606	0.01792
DES	3252	0.362882	0.83058	0.01456
LEV	25288	0.249126	0.79500	0.00500

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.000000	0.007236	0.120993
DES	-0.00724	0.000000	0.113756
LEV	-0.12099	-0.11376	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34381

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.04434	-0.03964	0.087242
DES	-0.03964	-0.04929	0.076730
LEV	0.087242	0.076730	-0.01768

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4019	1.136064	0.3380860	0.2813107
DES	3252	0.830579	0.3257492	0.2739248
LEV	25288	0.795003	0.2205126	0.1819284

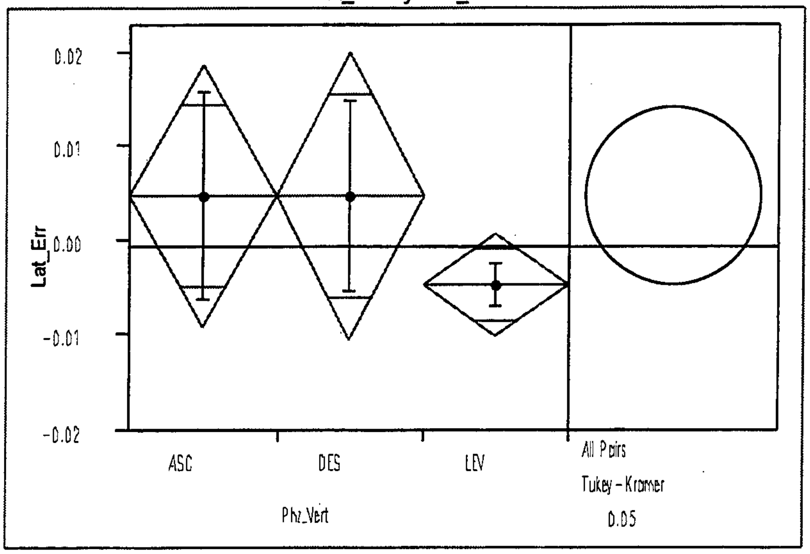
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.3366	2	32556	0.0967
Brown-Forsythe	37.5207	2	32556	<.0001
Levene	54.2052	2	32556	<.0001
Bartlett	523.9514	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
44.5759	2	5691.2	<.0001

Figure A.2- 137 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4019	0.007652	0.716016	0.01129
DES	3252	0.007661	0.582285	0.01021
LEV	25288	-0.00172	0.375069	0.00236

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	ASC	LEV
DES	0.000000	0.000009	0.009380
ASC	-9.13e-6	0.000000	0.009371
LEV	-0.00938	-0.00937	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34381

Abs(Dif)-LSD	DES	ASC	LEV
DES	-0.02641	-0.02511	-0.01046
ASC	-0.02511	-0.02375	-0.00871
LEV	-0.01046	-0.00871	-0.00947

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4019	0.7160160	0.1714768	0.1705436
DES	3252	0.5822854	0.1895395	0.1883966
LEV	25288	0.3750692	0.1111693	0.1111493

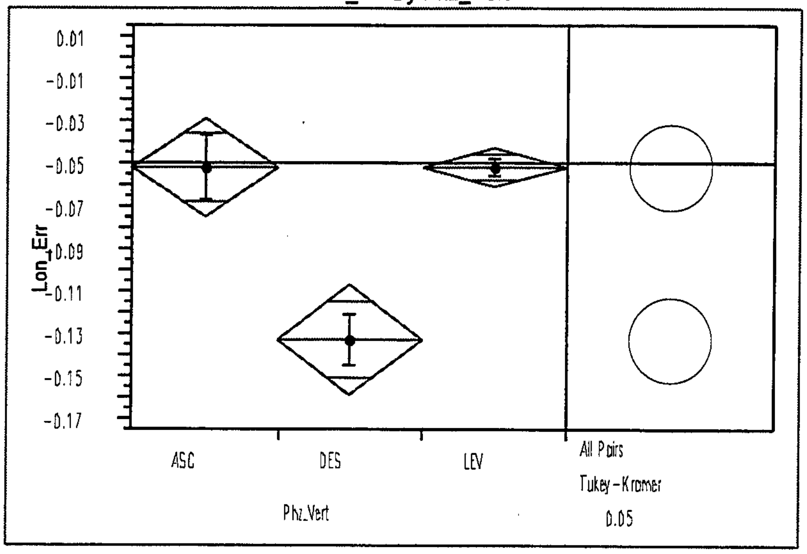
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	11.6147	2	32556	<.0001
Brown-Forsythe	69.0923	2	32556	<.0001
Levene	71.2014	2	32556	<.0001
Bartlett	2211.8958	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.6983	2	5247.3	0.4975

Figure A.2- 138 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4019	-0.04291	0.955554	0.01507
DES	3252	-0.11723	0.684633	0.01201
LEV	25288	-0.04202	0.742731	0.00467

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.000000	0.000891	0.075202
ASC	-0.00089	0.000000	0.074311
DES	-0.0752	-0.07431	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34381

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-0.01598	-0.02963	0.041721
ASC	-0.02963	-0.04009	0.031921
DES	0.041721	0.031921	-0.04457

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

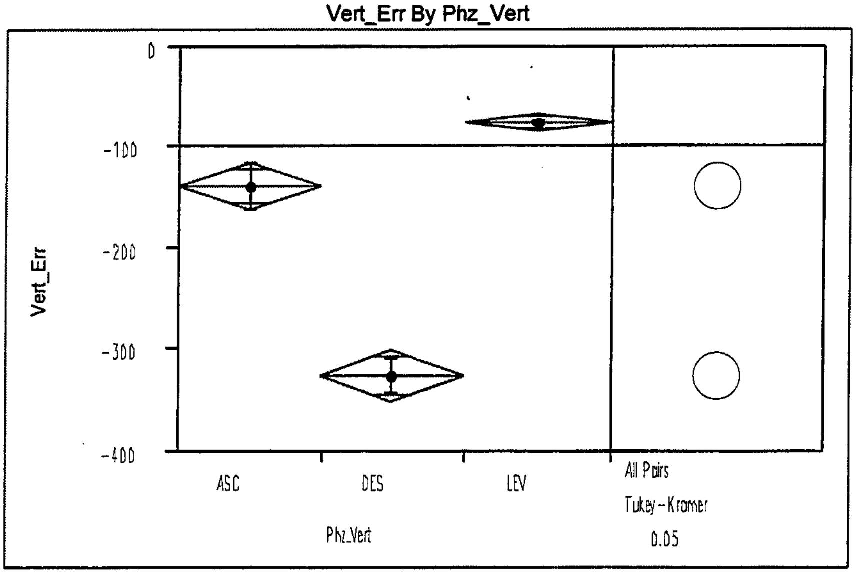
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4019	0.9555537	0.2802567	0.2797467
DES	3252	0.6846330	0.2566226	0.2492945
LEV	25288	0.7427308	0.1867056	0.1866858

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.9426	2	32556	0.3896
Brown-Forsythe	34.2053	2	32556	<.0001
Levene	36.6214	2	32556	<.0001
Bartlett	290.5073	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
17.2019	2	5911.8	<.0001

Figure A.2- 139 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	4019	-126.129	1474.88	23.265
DES	3252	-322.302	1002.40	17.578
LEV	25288	-65.622	563.81	3.545

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.000	60.507	256.679
ASC	-60.507	0.000	196.173
DES	-256.679	-196.173	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34381

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-16.356	29.276	222.418
ASC	29.276	-41.027	152.794
DES	222.418	152.794	-45.609

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	4019	1474.884	335.4700	298.8143
DES	3252	1002.402	398.4713	335.1945
LEV	25288	563.811	145.4466	103.0482

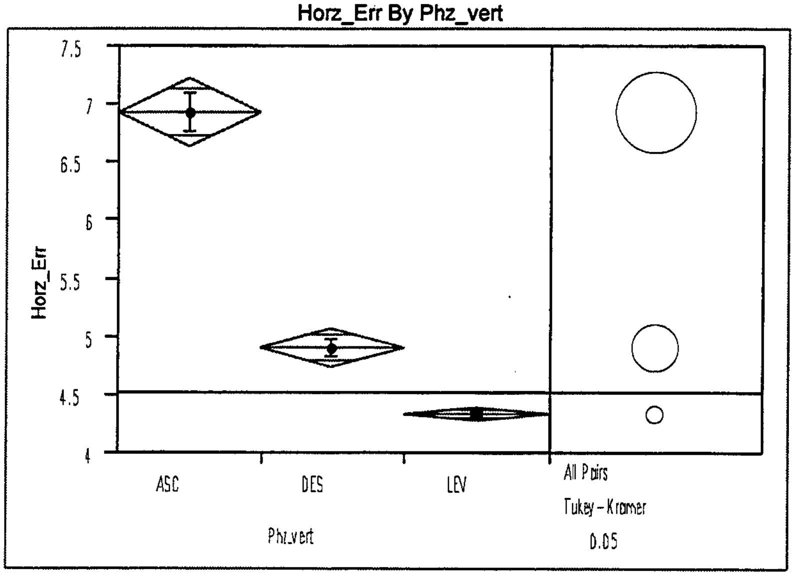
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	37.7008	2	32556	<.0001
Brown-Forsythe	215.7726	2	32556	<.0001
Levene	242.3140	2	32556	<.0001
Bartlett	5026.4204	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
104.7353	2	5100.8	<.0001

Figure A.2- 140 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at All Altitudes

Horz_Err By Phz_vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	1014	6.92099	5.81365	0.18257
DES	2875	4.90505	4.70164	0.08769
LEV	17990	4.33287	4.90285	0.03655

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	2.01594	2.58812
DES	-2.01594	0.00000	0.57218
LEV	-2.58812	-0.57218	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34386

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.51246	1.59450	2.21569
DES	1.59450	-0.30434	0.34042
LEV	2.21569	0.34042	-0.12166

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	1014	5.813647	4.087130	3.937372
DES	2875	4.701637	3.268421	3.065992
LEV	17990	4.902850	3.396693	3.078998

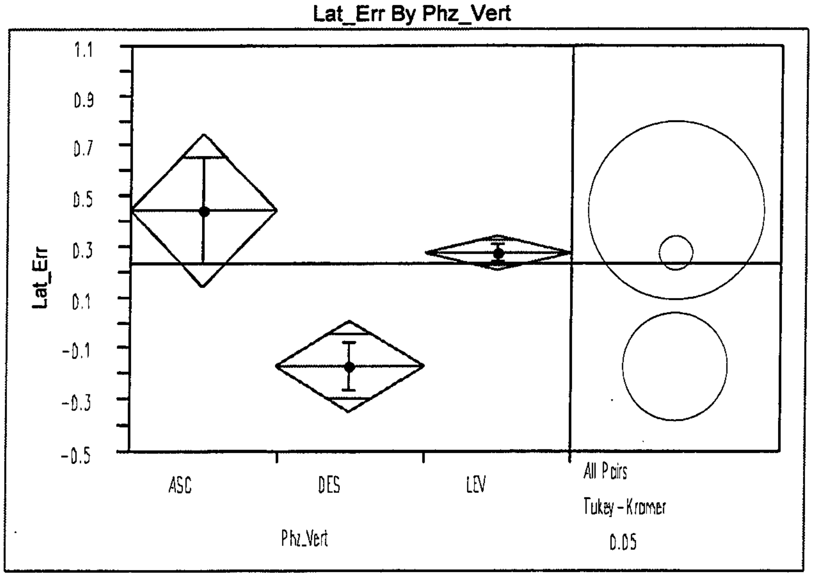
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.1194	2	21876	0.0022
Brown-Forsythe	20.7468	2	21876	<.0001
Levene	20.9098	2	21876	<.0001
Bartlett	37.5879	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
109.0111	2	2259.5	<.0001

Figure A.2- 141 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	1014	0.451527	6.73740	0.21158
DES	2875	-0.17616	5.13148	0.09570
LEV	17990	0.289807	4.89881	0.03652

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000000	0.161720	0.627690
LEV	-0.16172	0.000000	0.465970
DES	-0.62769	-0.46597	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34386

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.52354	-0.21877	0.197128
LEV	-0.21877	-0.1243	0.229198
DES	0.197128	0.229198	-0.31092

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

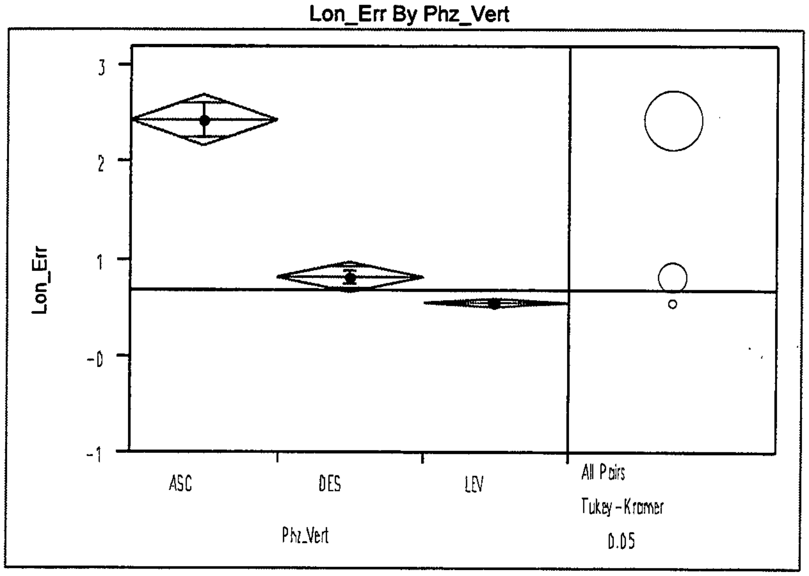
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	1014	6.737396	3.656798	3.600371
DES	2875	5.131484	3.037528	3.028863
LEV	17990	4.898810	2.596783	2.543725

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	26.5479	2	21876	<.0001
Brown-Forsythe	41.9461	2	21876	<.0001
Levene	40.3832	2	21876	<.0001
Bartlett	119.6425	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
10.8745	2	2211.1	<.0001

Figure A.2- 142 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	1014	2.03590	5.65689	0.17765
DES	2875	0.43200	4.42983	0.08262
LEV	17990	0.17391	4.32437	0.03224

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	1.60389	1.86198
DES	-1.60389	0.00000	0.25809
LEV	-1.86198	-0.25809	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34386

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.45893	1.22647	1.52845
DES	1.22647	-0.27255	0.05054
LEV	1.52845	0.05054	-0.10896

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

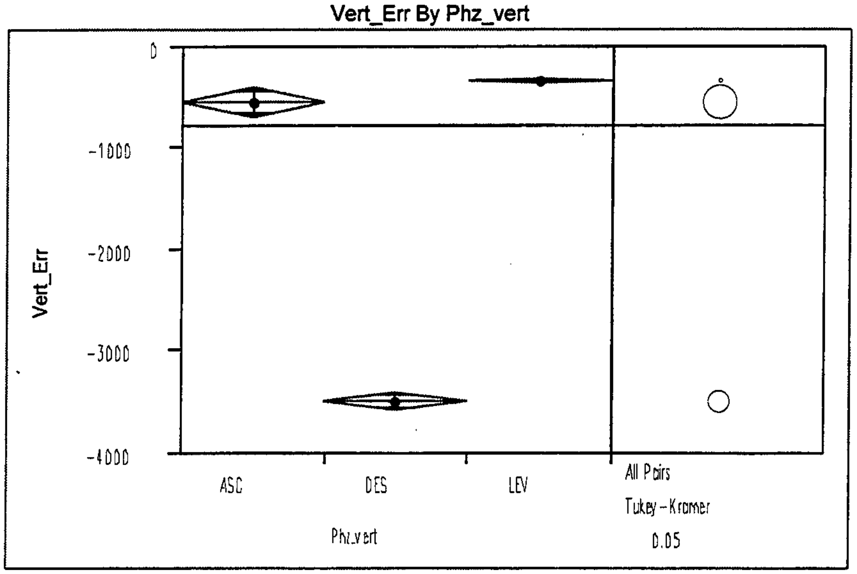
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	1014	5.656888	4.274895	4.269476
DES	2875	4.429833	2.968034	2.966377
LEV	17990	4.324370	2.691423	2.690756

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	15.8088	2	21876	<.0001
Brown-Forsythe	108.0990	2	21876	<.0001
Levene	108.8836	2	21876	<.0001
Bartlett	81.5364	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
55.6820	2	2224.6	<.0001

Figure A.2- 143 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	1014	-539.09	4371.02	137.27
DES	2875	-3485.95	3520.40	65.66
LEV	17990	-335.96	2325.02	17.33

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.00	203.13	3149.99
ASC	-203.13	0.00	2946.86
DES	-3149.99	-2946.86	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34386

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-65.19	3.57	3025.81
ASC	3.57	-274.58	2721.04
DES	3025.81	2721.04	-163.07

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

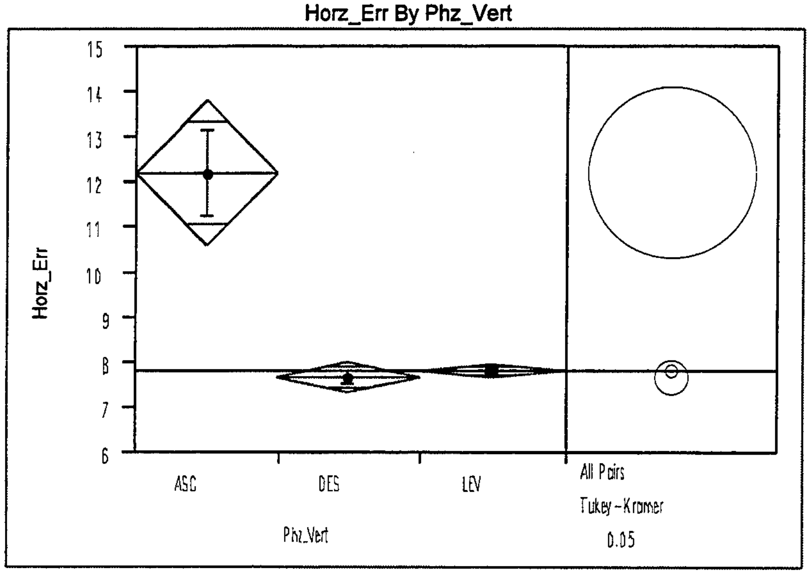
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	1014	4371.022	3055.845	3004.434
DES	2875	3520.404	2667.354	2646.650
LEV	17990	2325.024	1222.506	1032.262

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	227.5370	2	21876	<.0001
Brown-Forsythe	965.9416	2	21876	0.0000
Levene	889.3714	2	21876	0.0000
Bartlett	929.3615	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1075.5693	2	2110.7	0.0000

Figure A.2- 144 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	97	12.2024	9.49693	0.96427
DES	1855	7.6666	8.00219	0.18580
LEV	10954	7.8108	8.11594	0.07754

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	4.39161	4.53580
LEV	-4.39161	0.00000	0.14419
DES	-4.53580	-0.14419	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34397

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2.72991	2.45274	2.55564
LEV	2.45274	-0.25689	-0.33313
DES	2.55564	-0.33313	-0.62426

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

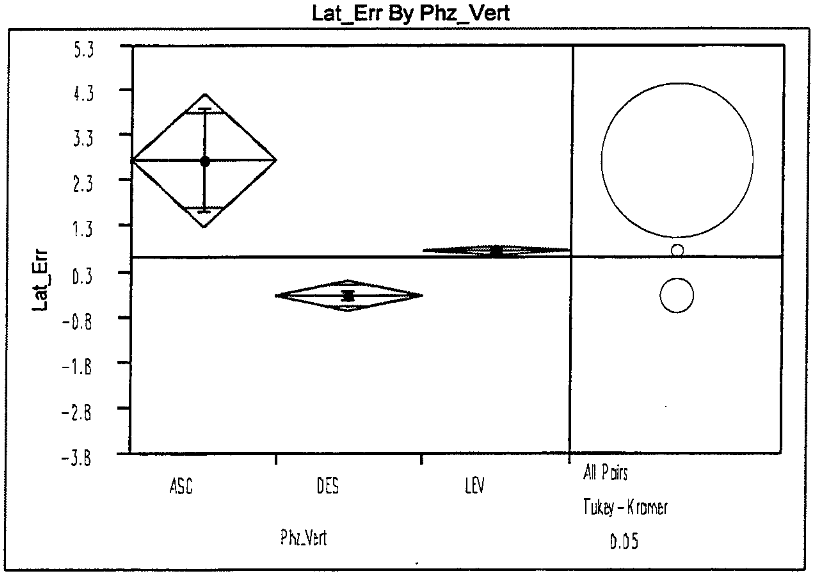
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	97	9.496933	7.517472	7.247739
DES	1855	8.002193	5.154240	4.824625
LEV	10954	8.115937	5.901777	5.451606

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.5803	2	12903	0.5598
Brown-Forsythe	10.8876	2	12903	<.0001
Levene	18.3378	2	12903	<.0001
Bartlett	2.9950	2	?	0.0500

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
10.6430	2	249.29	<.0001

Figure A.2- 145 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	97	2.70167	11.5912	1.1769
DES	1855	-0.29394	6.0832	0.1412
LEV	10954	0.68794	7.6128	0.0727

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	2.01373	2.99561
LEV	-2.01373	0.00000	0.98188
DES	-2.99561	-0.98188	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34397

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2.50773	0.23266	1.17661
LEV	0.23266	-0.23598	0.54340
DES	1.17661	0.54340	-0.57345

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	97	11.59116	7.512274	6.667173
DES	1855	6.08316	3.632251	3.603511
LEV	10954	7.61284	4.116118	3.946437

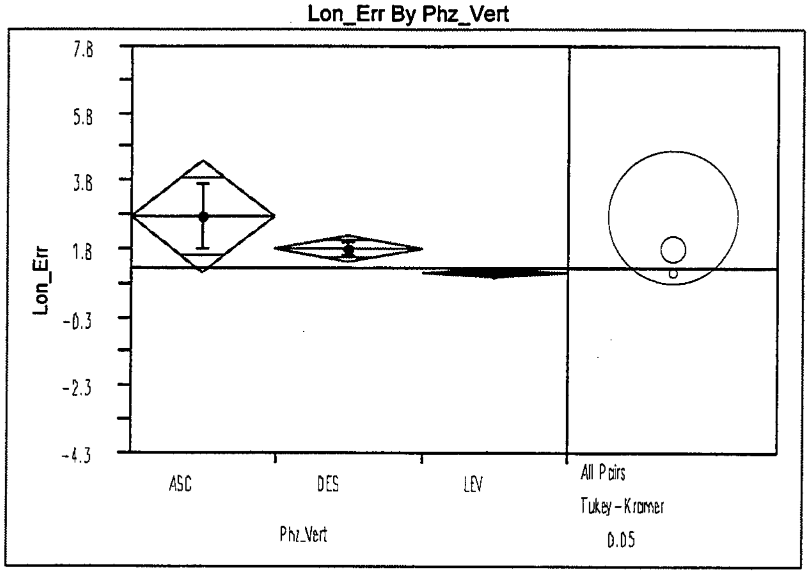
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	14.9438	2	12903	<.0001
Brown-Forsythe	11.4096	2	12903	<.0001
Levene	19.6871	2	12903	<.0001
Bartlett	97.6154	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
20.8162	2	249.32	<.0001

Figure A.2- 146 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	97	2.74775	9.55421	0.97008
DES	1855	1.74545	9.09419	0.21115
LEV	10954	1.09250	8.20124	0.07836

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	1.00230	1.65525
DES	-1.00230	0.00000	0.65296
LEV	-1.65525	-0.65296	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34397

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-2.80910	-1.03531	-0.33986
DES	-1.03531	-0.64236	0.16178
LEV	-0.33986	0.16178	-0.26434

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

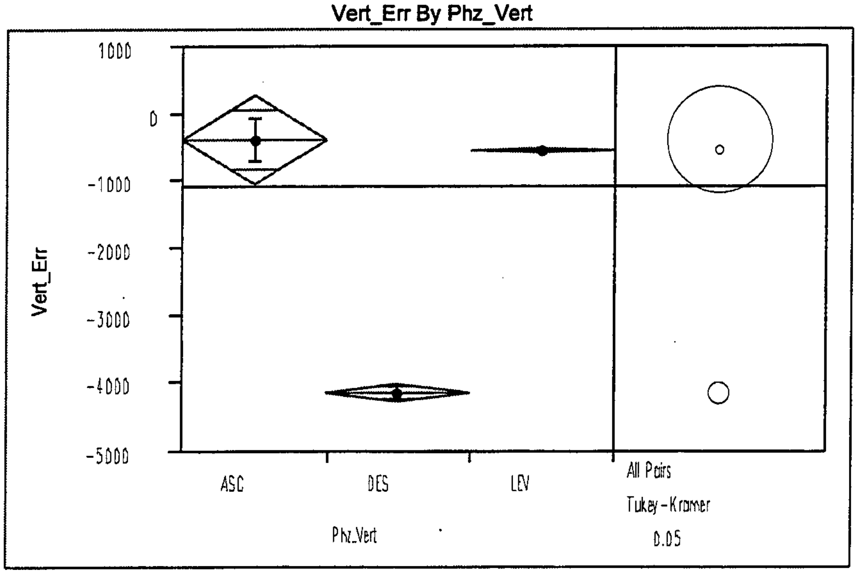
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	97	9.554211	7.570830	7.564773
DES	1855	9.094186	5.574221	5.554658
LEV	10954	8.201244	5.388095	5.365922

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.0377	2	12903	0.0177
Brown-Forsythe	6.2877	2	12903	0.0019
Levene	6.2617	2	12903	0.0019
Bartlett	19.6847	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
5.5004	2	248.83	0.0046

Figure A.2- 147 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	97	-380.64	3302.06	335.27
DES	1855	-4145.37	4589.18	106.55
LEV	10954	-536.90	3093.46	29.56

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	156.26	3764.73
LEV	-156.26	0.00	3608.47
DES	-3764.73	-3608.47	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34397

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-1127.93	-644.83	2946.58
LEV	-644.83	-106.14	3411.25
DES	2946.58	3411.25	-257.93

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	97	3302.064	2423.605	2407.041
DES	1855	4589.176	3334.635	3306.054
LEV	10954	3093.459	1740.157	1461.890

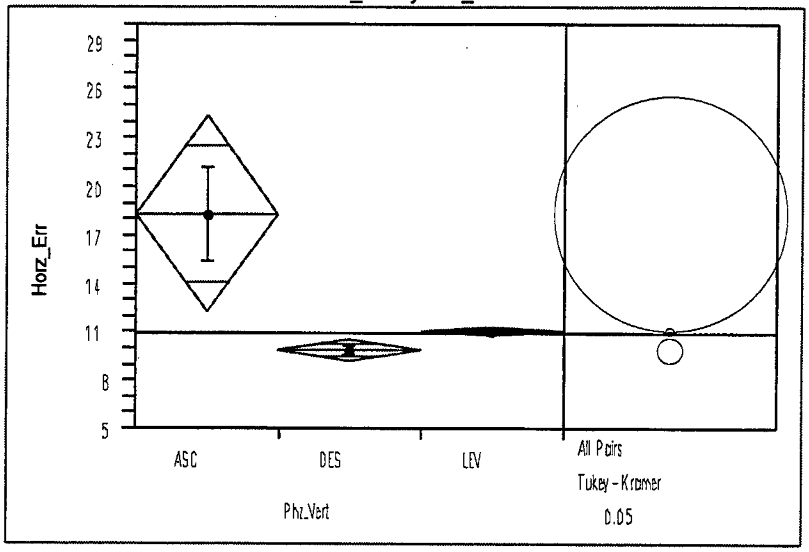
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	68.3927	2	12903	<.0001
Brown-Forsythe	336.2527	2	12903	<.0001
Levene	288.7853	2	12903	<.0001
Bartlett	294.5648	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
531.8025	2	248.43	<.0001

Figure A.2- 148 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at All Altitudes

Horz_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	18.4117	10.8303	3.0038
DES	899	10.0099	10.1100	0.3372
LEV	5740	11.0734	11.3750	0.1501

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	7.33828	8.40179
LEV	-7.33828	0.00000	1.06351
DES	-8.40179	-1.06351	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34423

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-10.3087	0.0407	1.0599
LEV	0.0407	-0.4906	0.1208
DES	1.0599	0.1208	-1.2396

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	10.83032	7.995225	8.020500
DES	899	10.10995	6.983412	6.383636
LEV	5740	11.37495	8.383543	7.734759

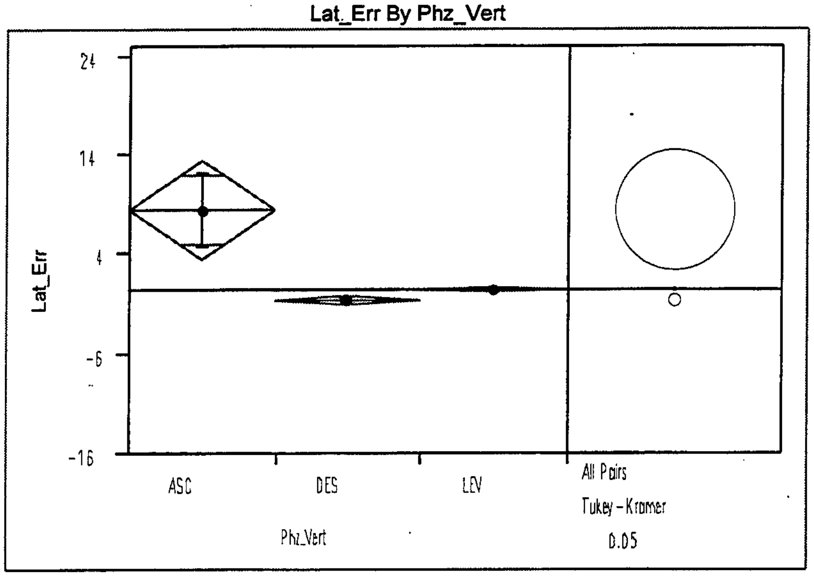
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.0972	2	6649	0.1229
Brown-Forsythe	8.4349	2	6649	0.0002
Levene	13.0717	2	6649	<.0001
Bartlett	10.0616	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
7.1244	2	31.834	0.0028

Figure A.2- 149 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	8.51086	13.9478	3.8684
DES	899	-0.58525	7.8343	0.2613
LEV	5740	0.59977	9.5891	0.1266

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	7.91109	9.09611
LEV	-7.91109	0.00000	1.18501
DES	-9.09611	-1.18501	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34423

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-8.62586	1.80479	2.95276
LEV	1.80479	-0.41050	0.39620
DES	2.95276	0.39620	-1.03728

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

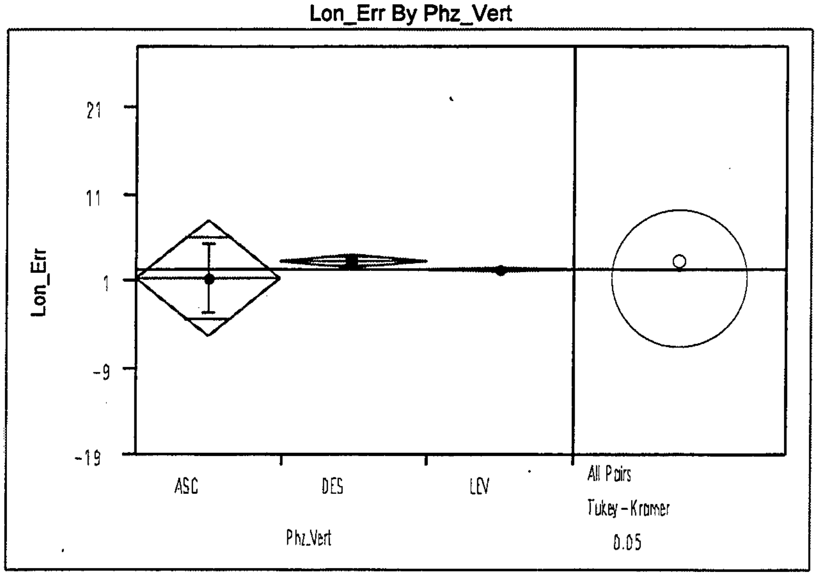
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	13.94780	11.74387	11.76735
DES	899	7.83429	4.67286	4.55423
LEV	5740	9.58914	5.03219	4.90163

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	3.4555	2	6649	0.0316
Brown-Forsythe	5.5253	2	6649	0.0040
Levene	5.5092	2	6649	0.0041
Bartlett	30.8193	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
10.3232	2	31.774	0.0004

Figure A.2- 150 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	1.44341	14.4660	4.0122
DES	899	3.23863	11.4150	0.3807
LEV	5740	2.30849	12.4254	0.1640

Means Comparisons

Dif=Mean[i]-Mean[j]	DES	LEV	ASC
DES	0.00000	0.93013	1.79522
LEV	-0.93013	0.00000	0.86509
ASC	-1.79522	-0.86509	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34423

Abs(Dif)-LSD	DES	LEV	ASC
DES	-1.3598	-0.1039	-6.2581
LEV	-0.1039	-0.5381	-7.1397
ASC	-6.2581	-7.1397	-11.3076

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

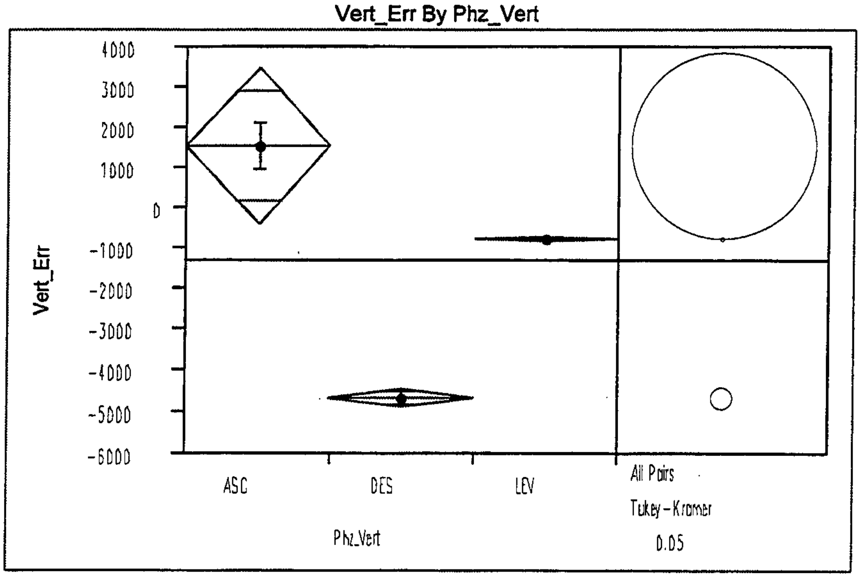
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	14.46603	11.37245	11.36032
DES	899	11.41499	7.49707	7.37398
LEV	5740	12.42540	8.27380	8.15128

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.5218	2	6649	0.2184
Brown-Forsythe	3.4678	2	6649	0.0312
Levene	3.5718	2	6649	0.0282
Bartlett	5.6347	2	?	0.0036

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.4966	2	31.785	0.0984

Figure A.2- 151 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	1569.38	2217.34	614.98
DES	899	-4666.23	4881.61	162.81
LEV	5740	-741.66	3393.31	44.79

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	2311.05	6235.62
LEV	-2311.05	0.00	3924.57
DES	-6235.62	-3924.57	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34423

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-3336.33	-50.77	3859.48
LEV	-50.77	-158.78	3619.47
DES	3859.48	3619.47	-401.20

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

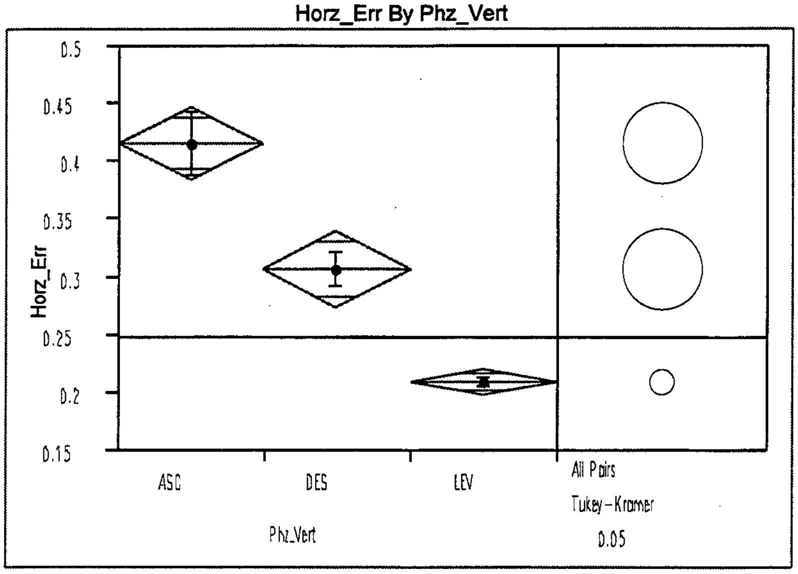
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	2217.340	1651.030	1617.077
DES	899	4881.614	3663.617	3614.791
LEV	5740	3393.309	2069.711	1699.630

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	38.2003	2	6649	<.0001
Brown-Forsythe	151.0714	2	6649	<.0001
Levene	129.4422	2	6649	<.0001
Bartlett	122.3683	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
273.1920	2	31.943	<.0001

Figure A.2- 152 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at All Altitudes



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2202	0.422096	1.34263	0.02861
DES	1812	0.306551	0.69023	0.01621
LEV	17151	0.220674	0.64413	0.00492

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.000000	0.115545	0.201422
DES	-0.11554	0.000000	0.085878
LEV	-0.20142	-0.08588	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34387

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.05307	0.059689	0.161558
DES	0.059689	-0.05851	0.042377
LEV	0.161558	0.042377	-0.01902

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

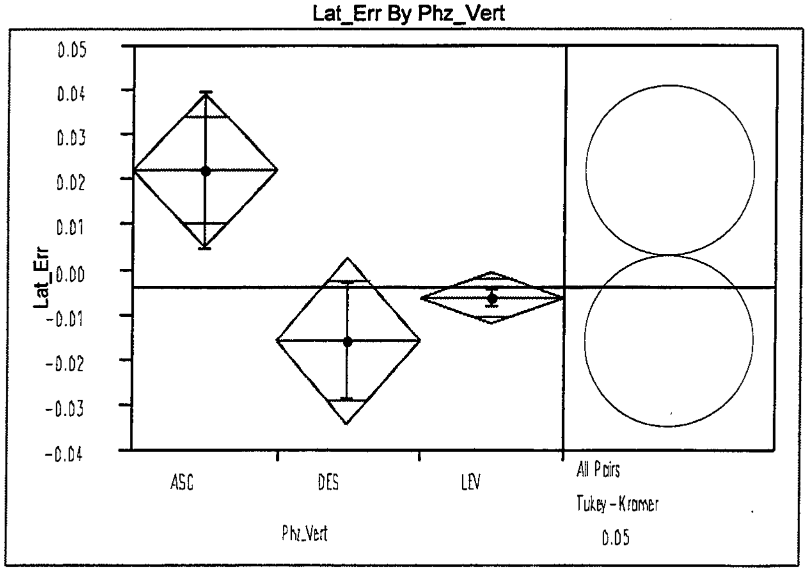
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2202	1.342634	0.4169606	0.3333033
DES	1812	0.690227	0.2575815	0.2205308
LEV	17151	0.644126	0.1764805	0.1506448

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.6705	2	21162	0.0094
Brown-Forsythe	63.2918	2	21162	<.0001
Levene	114.1045	2	21162	<.0001
Bartlett	1515.9052	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
35.2595	2	2973.9	<.0001

Figure A.2- 153 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2202	0.024691	0.840207	0.01791
DES	1812	-0.01042	0.548250	0.01288
LEV	17151	-0.00357	0.294129	0.00225

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000000	0.028265	0.035107
LEV	-0.02826	0.000000	0.006843
DES	-0.03511	-0.00684	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34387

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.02906	0.006436	0.004522
LEV	0.006436	-0.01041	-0.01698
DES	0.004522	-0.01698	-0.03204

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2202	0.8402071	0.1928937	0.1879958
DES	1812	0.5482501	0.1592899	0.1585052
LEV	17151	0.2941291	0.0938289	0.0936644

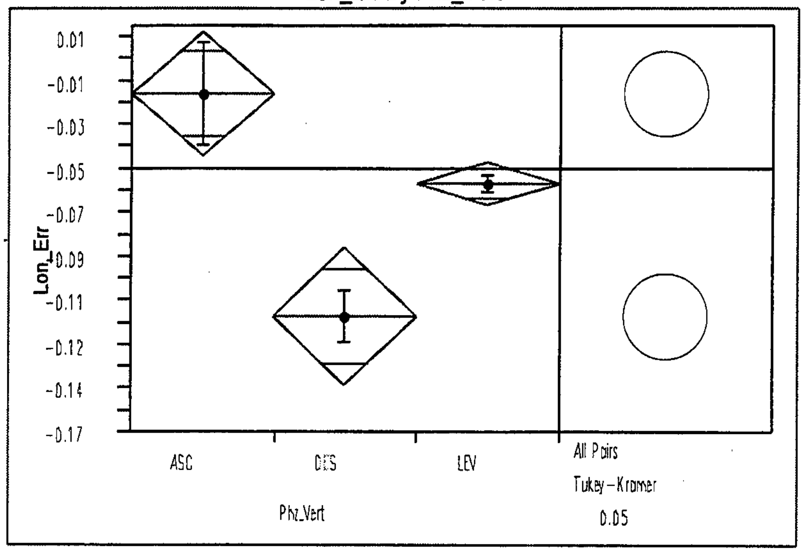
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	16.2492	2	21162	<.0001
Brown-Forsythe	71.0257	2	21162	<.0001
Levene	76.9380	2	21162	<.0001
Bartlett	3662.7047	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
1.3815	2	2773.6	0.2514

Figure A.2- 154 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2202	-0.01037	1.12883	0.02406
DES	1812	-0.09327	0.51093	0.01200
LEV	17151	-0.04388	0.61249	0.00468

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.000000	0.033507	0.082895
LEV	-0.03351	0.000000	0.049388
DES	-0.08289	-0.04939	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34387

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.04785	-0.00244	0.032534
LEV	-0.00244	-0.01715	0.010167
DES	0.032534	0.010167	-0.05275

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

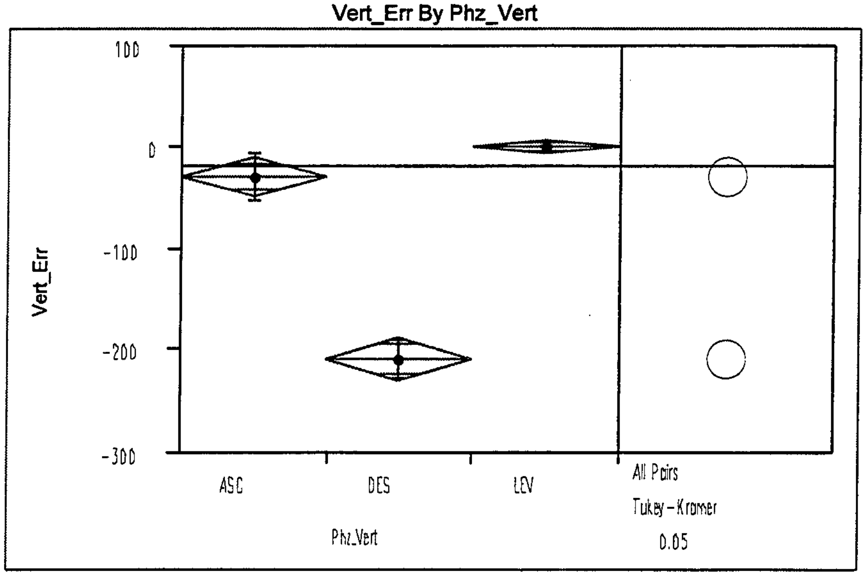
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2202	1.128826	0.3302633	0.3275759
DES	1812	0.510930	0.2119499	0.2104763
LEV	17151	0.612493	0.1669001	0.1668973

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.4500	2	21162	0.0863
Brown-Forsythe	61.0119	2	21162	<.0001
Levene	63.2115	2	21162	<.0001
Bartlett	1114.5912	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
8.6873	2	3146	0.0002

Figure A.2- 155 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	2202	-23.475	1123.64	23.945
DES	1812	-202.305	833.07	19.570
LEV	17151	2.754	263.21	2.010

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.000	26.229	205.059
ASC	-26.229	0.000	178.830
DES	-205.059	-178.830	0.000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34387

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-12.575	-0.132	176.293
ASC	-0.132	-35.096	141.893
DES	176.293	141.893	-38.689

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	2202	1123.636	254.6128	250.7931
DES	1812	833.068	252.5226	227.5891
LEV	17151	263.211	32.9780	30.8177

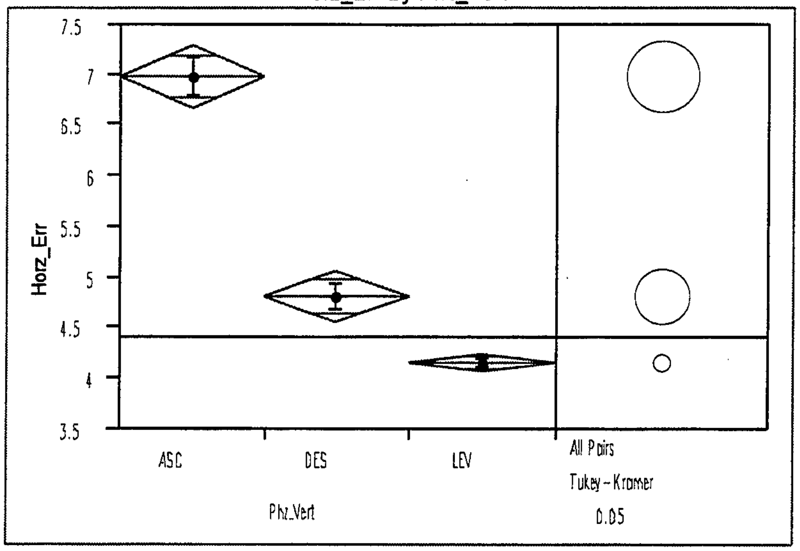
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	36.6913	2	21162	<.0001
Brown-Forsythe	303.4953	2	21162	<.0001
Levene	338.8610	2	21162	<.0001
Bartlett	8162.1553	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
54.8100	2	2696.6	<.0001

Figure A.2- 156 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 0 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	945	6.98980	5.93362	0.19302
DES	1540	4.82235	5.21500	0.13289
LEV	12296	4.16374	5.02739	0.04534

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	2.16744	2.82605
DES	-2.16744	0.00000	0.65861
LEV	-2.82605	-0.65861	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34394

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.55099	1.67253	2.42175
DES	1.67253	-0.43162	0.33486
LEV	2.42175	0.33486	-0.15275

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	945	5.933623	4.162648	3.996077
DES	1540	5.214998	3.500156	3.204339
LEV	12296	5.027388	3.389343	3.017383

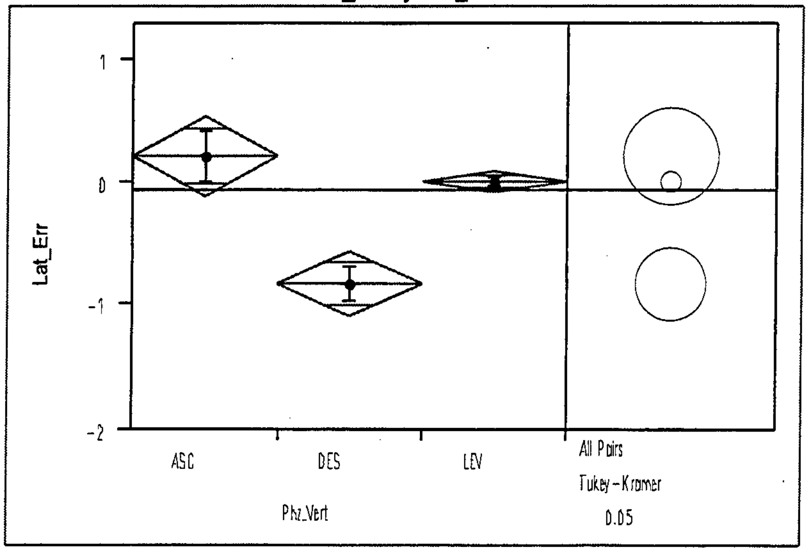
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.4606	2	14778	0.0116
Brown-Forsythe	22.0580	2	14778	<.0001
Levene	18.6727	2	14778	<.0001
Bartlett	27.2158	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
108.1923	2	1788.8	<.0001

Figure A.2- 157 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	945	0.628674	6.83593	0.22237
DES	1540	-0.41593	5.77308	0.14711
LEV	12296	0.398568	5.17147	0.04664

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	0.23011	1.04460
LEV	-0.23011	0.00000	0.81449
DES	-1.04460	-0.81449	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34394

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-0.57774	-0.19383	0.525653
LEV	-0.19383	-0.16017	0.475026
DES	0.525653	0.475026	-0.45257

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	945	6.835927	3.704871	3.608629
DES	1540	5.773082	3.412944	3.373358
LEV	12296	5.171465	2.675225	2.574678

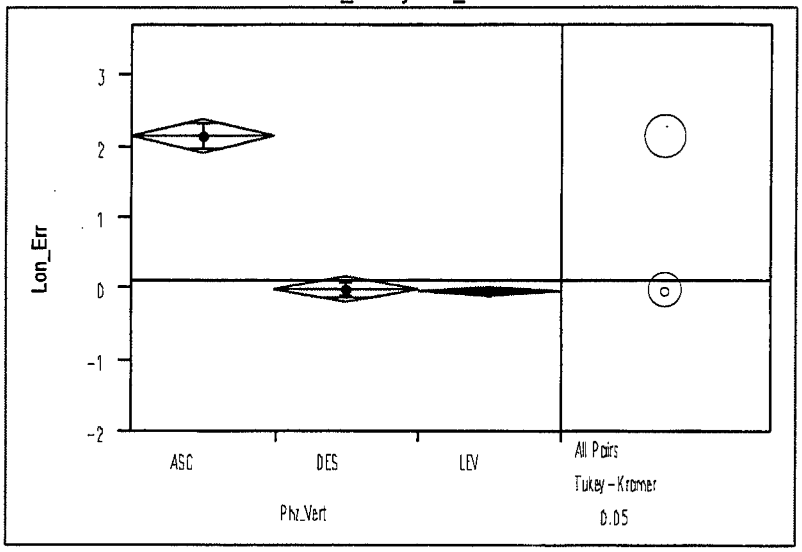
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	17.9586	2	14778	<.0001
Brown-Forsythe	38.9748	2	14778	<.0001
Levene	37.2465	2	14778	<.0001
Bartlett	90.4058	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.8229	2	1752.7	<.0001

Figure A.2- 158 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Lon_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	945	2.34529	5.61116	0.18253
DES	1540	0.19763	4.11409	0.10484
LEV	12296	0.17573	3.95967	0.03571

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	2.14766	2.16956
DES	-2.14766	0.00000	0.02190
LEV	-2.16956	-0.02190	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34394

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-0.44222	1.75045	1.84507
DES	1.75045	-0.34641	-0.23794
LEV	1.84507	-0.23794	-0.12259

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	945	5.611159	4.188685	4.184091
DES	1540	4.114089	2.545280	2.544765
LEV	12296	3.959669	2.435704	2.433590

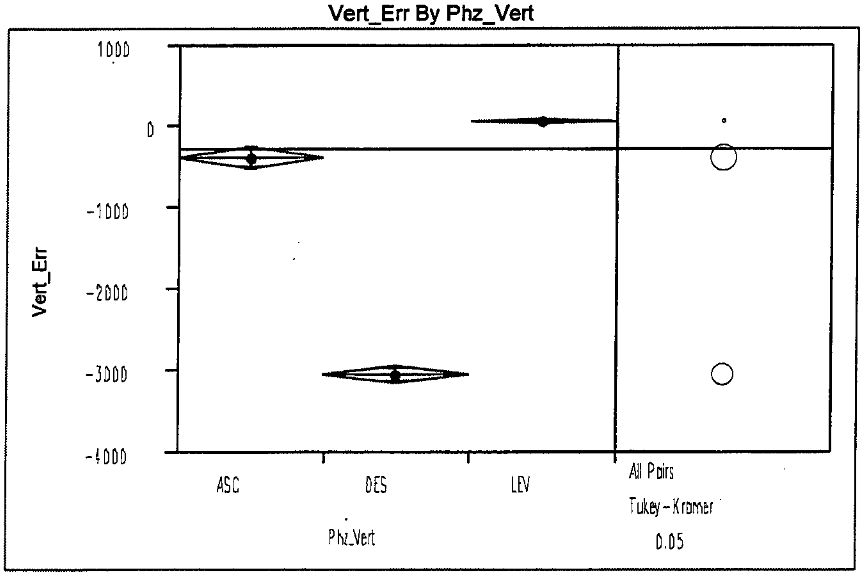
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	24.6430	2	14778	<.0001
Brown-Forsythe	133.0151	2	14778	<.0001
Levene	133.7116	2	14778	<.0001
Bartlett	130.4081	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
68.1467	2	1757.4	<.0001

Figure A.2- 159 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	945	-380.28	4319.61	140.52
DES	1540	-3032.69	3379.09	86.11
LEV	12296	65.83	2043.03	18.42

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.00	446.11	3098.52
ASC	-446.11	0.00	2652.41
DES	-3098.52	-2652.41	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34394

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-72.33	254.67	2945.23
ASC	254.67	-260.89	2418.07
DES	2945.23	2418.07	-204.37

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	945	4319.607	3002.328	2940.678
DES	1540	3379.094	2559.165	2542.165
LEV	12296	2043.027	779.610	737.421

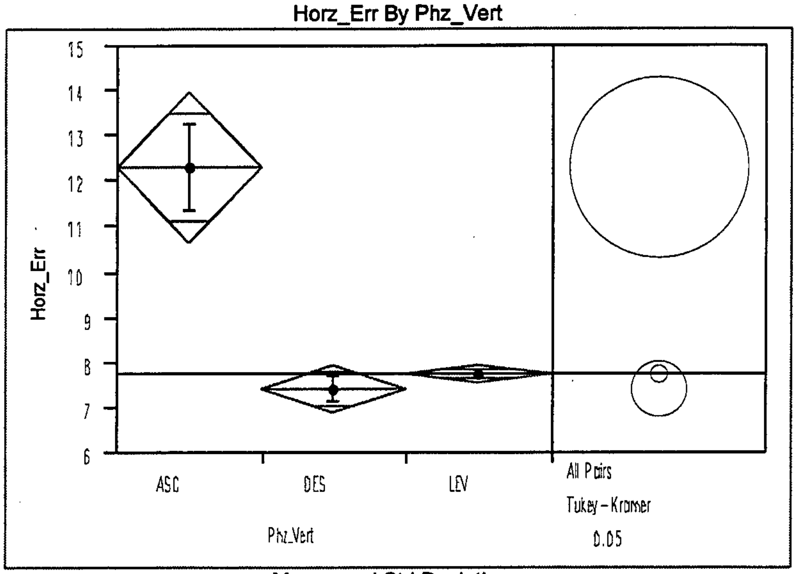
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	186.7679	2	14778	<.0001
Brown-Forsythe	948.1531	2	14778	0.0000
Levene	973.3493	2	14778	0.0000
Bartlett	1017.5161	2	?	0.0000

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
621.2446	2	1645.5	<.0001

Figure A.2- 160 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 600 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	95	12.3169	9.55293	0.98011
DES	856	7.4245	8.55565	0.29243
LEV	7223	7.7775	8.38689	0.09868

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	4.53939	4.89236
LEV	-4.53939	0.00000	0.35297
DES	-4.89236	-0.35297	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34413

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2.86349	2.50132	2.75817
LEV	2.50132	-0.32840	-0.36042
DES	2.75817	-0.36042	-0.95394

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	95	9.552931	7.586070	7.334192
DES	856	8.555648	5.319627	4.889017
LEV	7223	8.386888	6.017697	5.509816

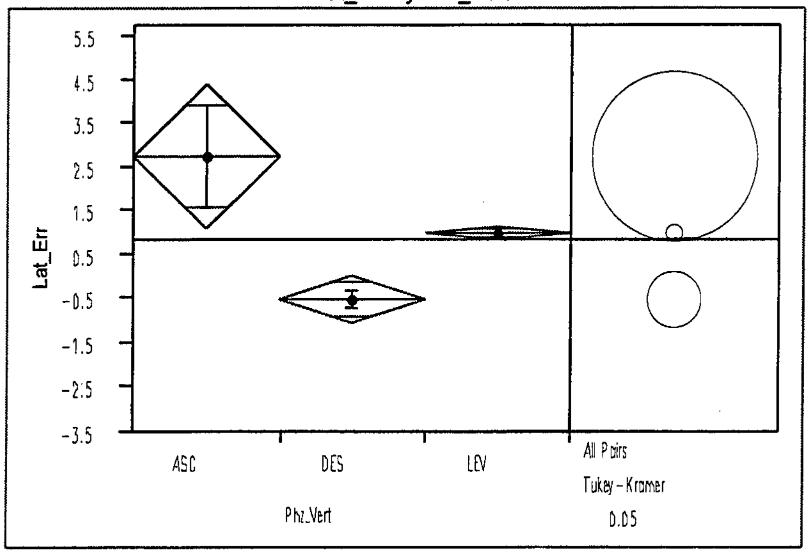
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.4071	2	8171	0.6656
Brown-Forsythe	6.3817	2	8171	0.0017
Levene	8.8861	2	8171	0.0001
Bartlett	1.9610	2	?	0.1407

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
11.4198	2	234.05	<.0001

Figure A.2- 161 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	95	2.78727	11.6949	1.1999
DES	856	-0.51335	6.5813	0.2249
LEV	7223	1.00169	8.3609	0.0984

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	1.78558	3.30063
LEV	-1.78558	0.00000	1.51504
DES	-3.30063	-1.51504	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34413

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2.80247	-0.20905	1.21191
LEV	-0.20905	-0.32140	0.81686
DES	1.21191	0.81686	-0.93361

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

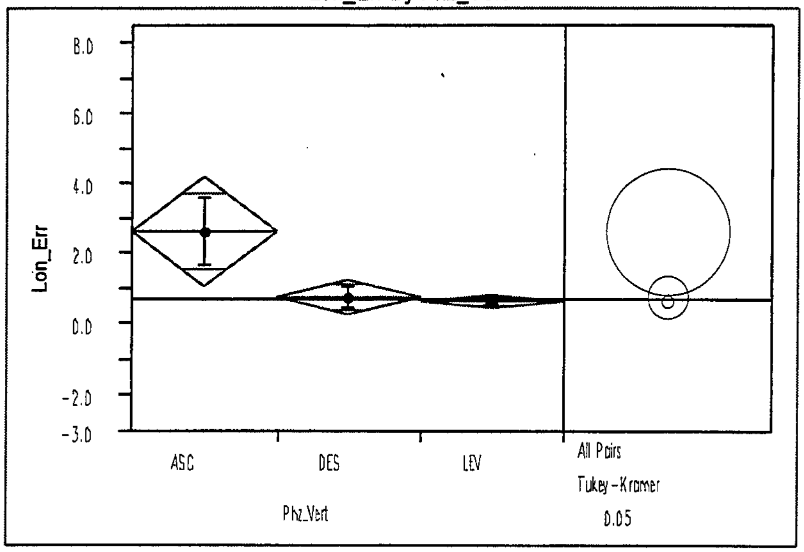
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	95	11.69487	7.620599	6.765580
DES	856	6.58134	3.961623	3.888615
LEV	7223	8.36086	4.579453	4.285086

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	8.2021	2	8171	0.0003
Brown-Forsythe	7.1040	2	8171	0.0008
Levene	12.7391	2	8171	<.0001
Bartlett	53.5887	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
20.4032	2	234.97	<.0001

Figure A.2- 162 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	95	2.71589	9.61780	0.98677
DES	856	0.81066	9.17341	0.31354
LEV	7223	0.67125	7.71231	0.09075

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.00000	1.90524	2.04465
DES	-1.90524	0.00000	0.13941
LEV	-2.04465	-0.13941	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34413

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-2.68763	-0.09789	0.13175
DES	-0.09789	-0.89535	-0.53017
LEV	0.13175	-0.53017	-0.30823

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

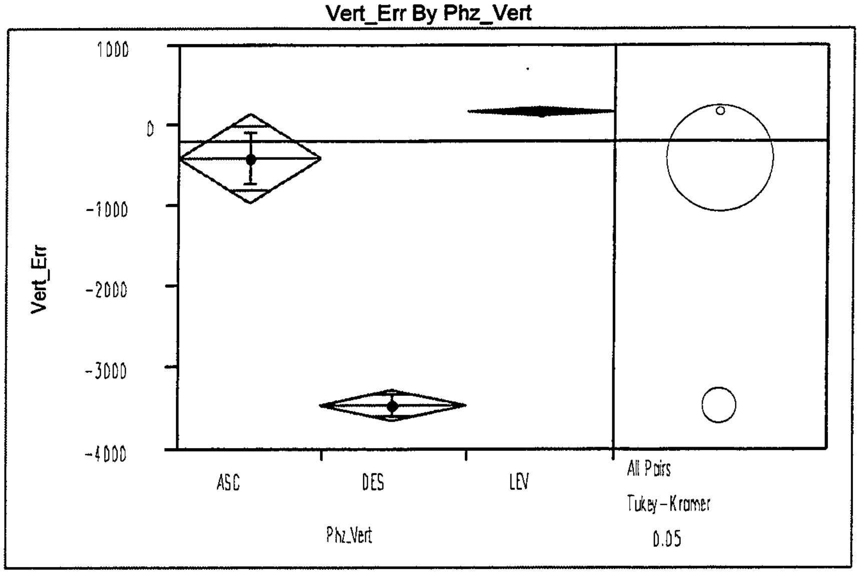
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	95	9.617799	7.612791	7.605600
DES	856	9.173409	5.150617	5.127945
LEV	7223	7.712305	5.014171	5.002155

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.3232	2	8171	0.0018
Brown-Forsythe	8.6664	2	8171	0.0002
Levene	8.7217	2	8171	0.0002
Bartlett	29.3676	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.1926	2	232.44	0.1139

Figure A.2- 163 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	95	-408.74	3331.19	341.77
DES	856	-3460.70	4468.07	152.72
LEV	7223	187.36	2589.29	30.47

Means Comparisons

Dif=Mean[i]-Mean[j]	LEV	ASC	DES
LEV	0.00	596.09	3648.06
ASC	-596.09	0.00	3051.96
DES	-3648.06	-3051.96	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34413

Abs(Dif)-LSD	LEV	ASC	DES
LEV	-111.30	-94.68	3406.27
ASC	-94.68	-970.53	2328.61
DES	3406.27	2328.61	-323.32

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	95	3331.191	2442.988	2422.905
DES	856	4468.066	3173.108	3159.027
LEV	7223	2589.291	1099.377	974.838

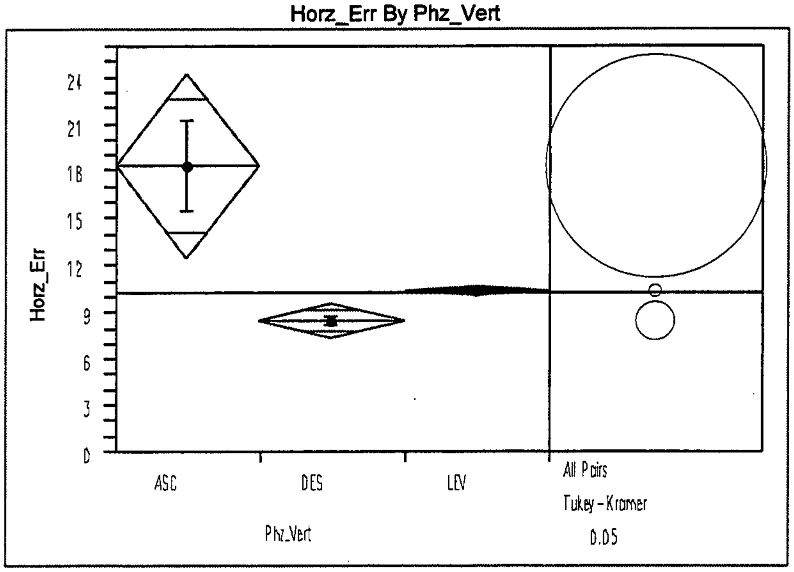
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	48.6677	2	8171	<.0001
Brown-Forsythe	303.9437	2	8171	<.0001
Levene	286.5383	2	8171	<.0001
Bartlett	303.1262	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
274.4881	2	230.68	<.0001

Figure A.2- 164 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1200 for Samples at Altitudes Above 18,000 Feet

Horz_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	18.4117	10.8303	3.0038
DES	392	8.5610	7.7092	0.3894
LEV	3507	10.5180	11.3798	0.1922

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	7.89373	9.85070
LEV	-7.89373	0.00000	1.95697
DES	-9.85070	-1.95697	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34460

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-10.1765	0.6846	2.5365
LEV	0.6846	-0.6196	0.5753
DES	2.5365	0.5753	-1.8532

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	10.83032	7.995225	8.020500
DES	392	7.70925	5.455350	5.193106
LEV	3507	11.37979	8.106691	7.402555

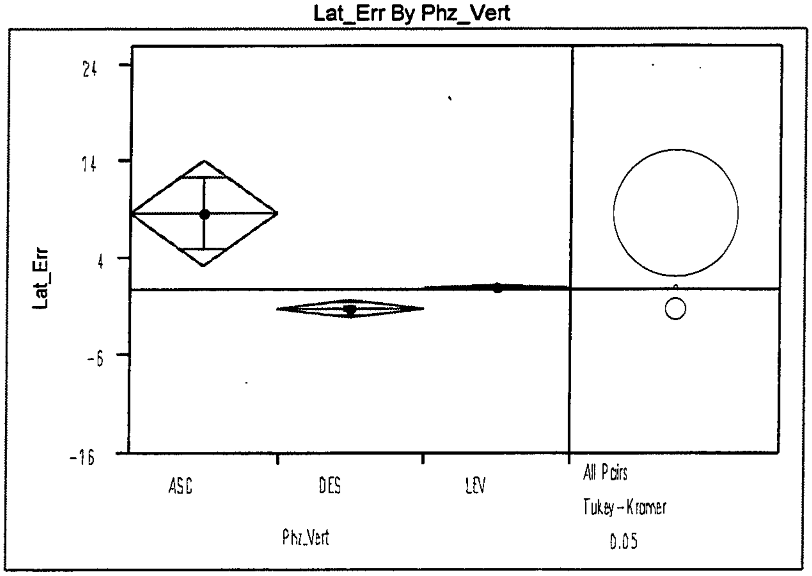
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.1623	2	3909	0.0021
Brown-Forsythe	10.1909	2	3909	<.0001
Levene	20.5557	2	3909	<.0001
Bartlett	42.8970	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
13.6521	2	31.575	<.0001

Figure A.2- 165 Statistical Tests for Horizontal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

Lat_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	8.51086	13.9478	3.8684
DES	392	-1.33389	8.2139	0.4149
LEV	3507	0.90741	10.4962	0.1772

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00000	7.60345	9.84475
LEV	-7.60345	0.00000	2.24130
DES	-9.84475	-2.24130	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34460

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-9.47522	0.89105	3.03457
LEV	0.89105	-0.57689	0.95480
DES	3.03457	0.95480	-1.72551

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

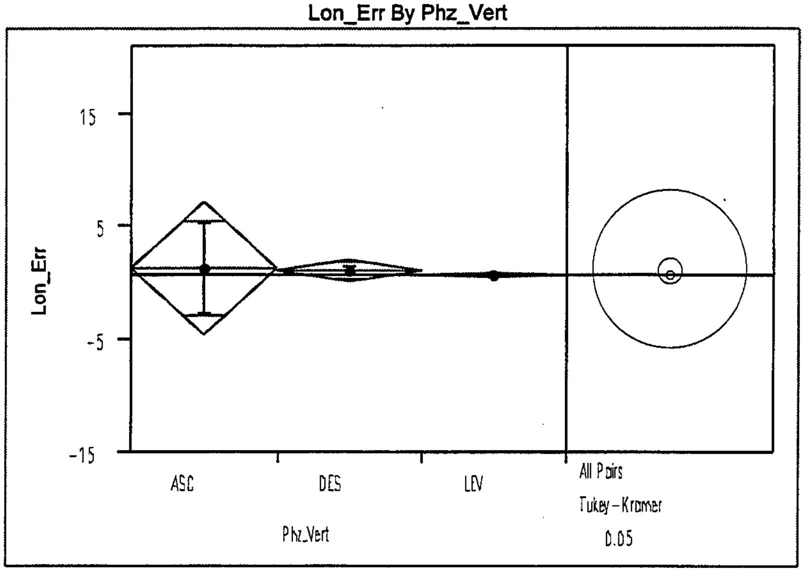
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	13.94780	11.74387	11.76735
DES	392	8.21390	5.21613	4.93337
LEV	3507	10.49624	5.51236	5.25194

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	2.0601	2	3909	0.1276
Brown-Forsythe	3.7195	2	3909	0.0243
Levene	3.5589	2	3909	0.0286
Bartlett	19.6651	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.1484	2	31.419	<.0001

Figure A.2- 166 Statistical Tests for Lateral Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	1.44341	14.4660	4.0122
DES	392	1.22113	7.8844	0.3982
LEV	3507	0.79997	11.3369	0.1914

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	DES	LEV
ASC	0.000000	0.222276	0.643442
DES	-0.22228	0.000000	0.421166
LEV	-0.64344	-0.42117	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34460

Abs(Dif)-LSD	ASC	DES	LEV
ASC	-10.1632	-7.0824	-6.5563
DES	-7.0824	-1.8508	-0.9588
LEV	-6.5563	-0.9588	-0.6188

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	14.46603	11.37245	11.36032
DES	392	7.88442	5.56505	5.56489
LEV	3507	11.33686	7.22808	7.19496

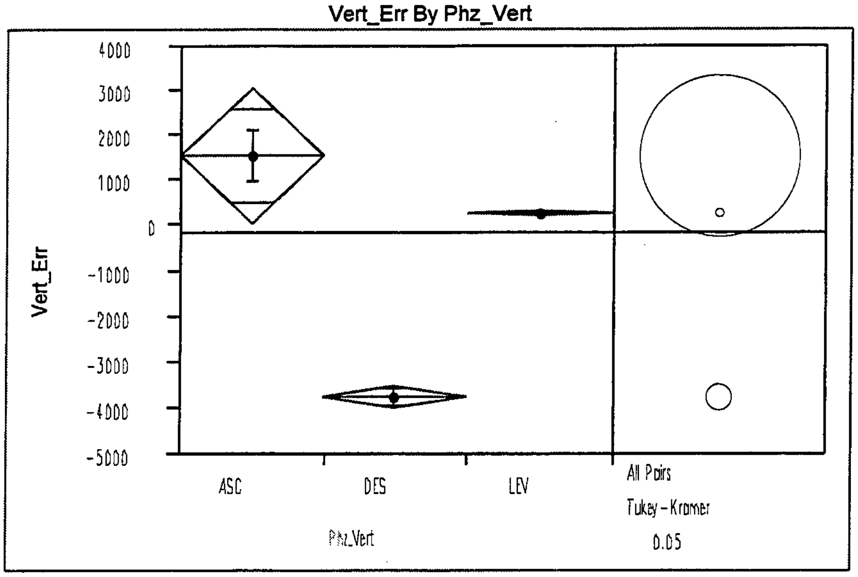
Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.6445	2	3909	0.0013
Brown-Forsythe	8.1257	2	3909	0.0003
Levene	8.4767	2	3909	0.0002
Bartlett	38.8478	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
0.4545	2	31.474	0.6388

Figure A.2- 167 Statistical Tests for Longitudinal Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

Vert_Err By Phz_Vert



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
ASC	13	1569.38	2217.34	614.98
DES	392	-3744.79	4239.04	214.10
LEV	3507	268.79	2607.02	44.02

Means Comparisons

Dif=Mean[i]-Mean[j]	ASC	LEV	DES
ASC	0.00	1300.60	5314.18
LEV	-1300.60	0.00	4013.58
DES	-5314.18	-4013.58	0.00

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q* = 2.34460

Abs(Dif)-LSD	ASC	LEV	DES
ASC	-2586.15	-531.48	3455.41
LEV	-531.48	-157.46	3662.44
DES	3455.41	3662.44	-470.96

Positive values show pairs of means that are significantly different.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
ASC	13	2217.340	1651.030	1617.077
DES	392	4239.042	3332.325	3316.254
LEV	3507	2607.018	1183.840	1011.159

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	21.7994	2	3909	<.0001
Brown-Forsythe	156.9285	2	3909	<.0001
Levene	147.2733	2	3909	<.0001
Bartlett	106.4583	2	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
167.8343	2	31.418	<.0001

Figure A.2- 168 Statistical Tests for Vertical Error and Vertical Phase of Flight at Look Ahead Time 1800 for Samples at Altitudes Above 18,000 Feet

Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/ Center-TRACON Automation System (CTAS)

APPENDIX B: Listing of Standard Deviation Plots

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APPENDIX B

B.0 Introduction

Appendix B is a supplement to *Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/Center-TRACON Automation System (CTAS), DOT/FAA/CT-TN99/10.* The Appendix B contains a super set list of Microsoft PowerPoint slides from the Enroute Area Work Team (ERAWT) quarterly meeting held April 20-21 at MITRE, where the preliminary analysis of this report was presented.

The PowerPoint slides provide the standard deviation (STD) for horizontal, lateral, longitudinal and vertical error by look ahead time for the flight categories analyzed in the report – flight type, horizontal and vertical error. Additional slides from the presentation that duplicate information provided earlier in this report have been excluded.

The remaining portions of this introduction to Appendix B summarize the slide sequence and provide a brief description of the slides and method used to calculate the STD statistics.

B.0.1. Appendix Layout

Appendix B presents the standard deviations as a function of look ahead time and in order of the particular trajectory modeler and three factor categories. These categories are listed in the PowerPoint slide headings, including flight type, horizontal and vertical phase of flight. Table B.0-1 summaries the slide sequence. Appendix Section B.1 contains slides pertaining to the URET trajectory modeler and Appendix B.2 provides slides for the CTAS modeler.

Table B.0- 1: Standard Deviation Slides by Trajectory Modeler

B.1	**URET**	**B.2**	**CTAS**
B.1.1	*Flight Type*	*B.2.1*	*Flight Type*
	Flight Type – All Altitudes Horizontal Error Lateral Error Longitudinal Error Vertical Error		*Flight Type – All Altitudes* Horizontal Error Lateral Error Longitudinal Error Vertical Error
	Flight Type – Above 18,000 Feet Horizontal Error Lateral Error Longitudinal Error Vertical Error		*Flight Type – Above 18,000 Feet* Horizontal Error Lateral Error Longitudinal Error Vertical Error
B.1.2	*Horizontal Phase of Flight*	*B.2.2*	*Horizontal Phase of Flight*
	Same sequence		Same sequence
B.1.3	*Vertical Phase of Flight*	*B.2.3*	*Vertical Phase of Flight*
	Same sequence		Same sequence

B.0.2. Description of PowerPoint Slides for STD

Figure B.0-1 is an example a PowerPoint slide for the standard deviation (STD) of the horizontal error for the flight type factor. The category along the horizontal axis for all STD slides is look ahead time. Look ahead time is shown in 600 second increments from 0 to 1800 seconds. The units along the vertical axis (not shown) are nautical miles for slides with horizontal, lateral, and longitudinal error and feet for slides with vertical error.

Comparable to the charts plotted for mean error in the body of the report in Sections 3.3 and 4.3, the following factors were plotted to evaluate standard deviation: overflights, arrivals, departures, and internal flights (i.e. OVR, ARR, DEP, and INR, respectively) for the flight type category, turn and straight for horizontal phase of flight (i.e. TRN and STR, respectively), and ascent, descent, and level flight for the vertical phase of flight (i.e. ASC, DES, and LEV, respectively).

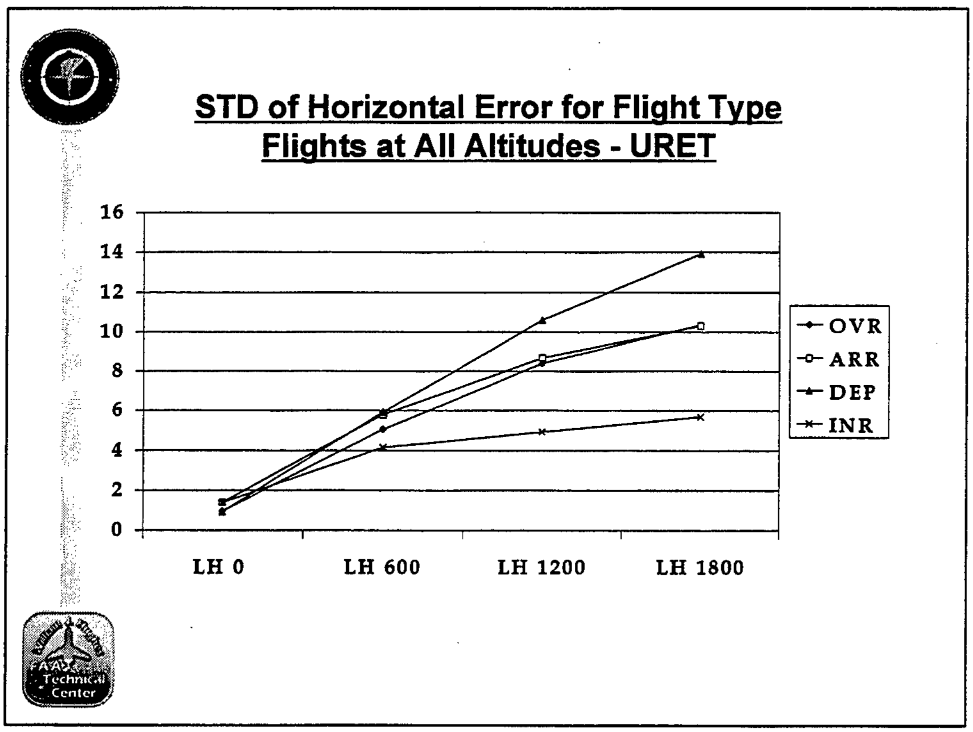


Figure B:0-1 Example of PowerPoint Slide for Standard Deviation

B.0.3. Definition of Standard Deviation

Standard deviation (STD) measures the spread of a distribution of observations about the mean. The sample standard deviation is calculated as the square root of the variance,

$$s^2 = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

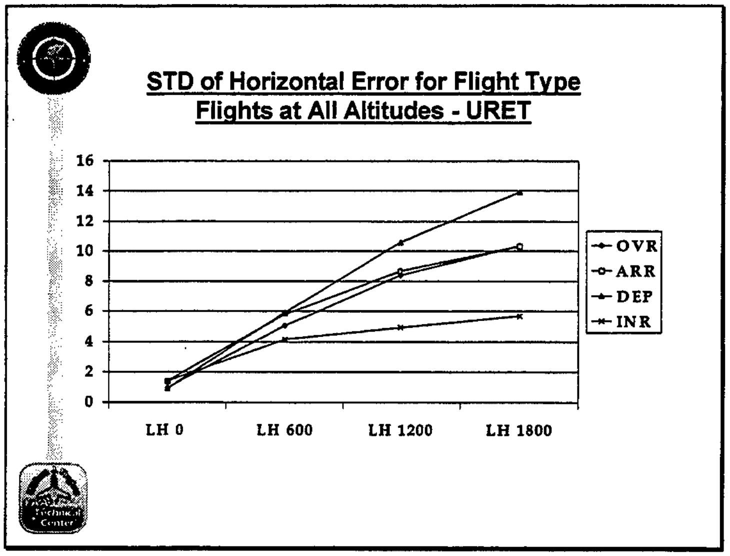
Equation B.0-1

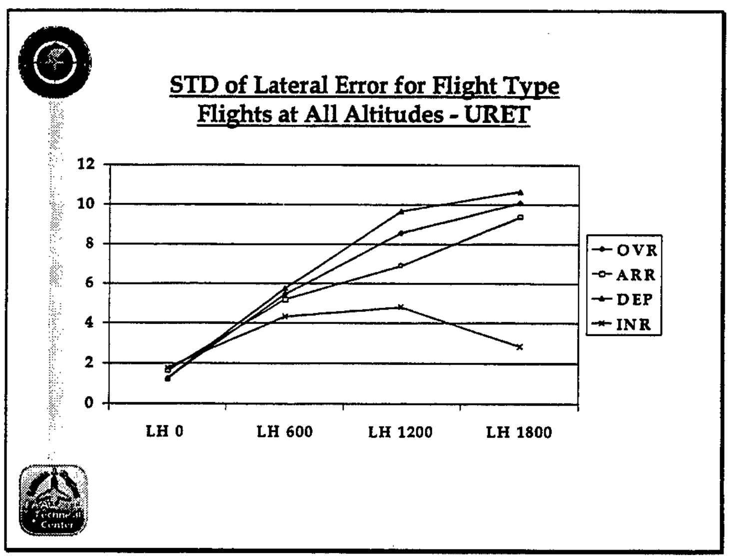
where

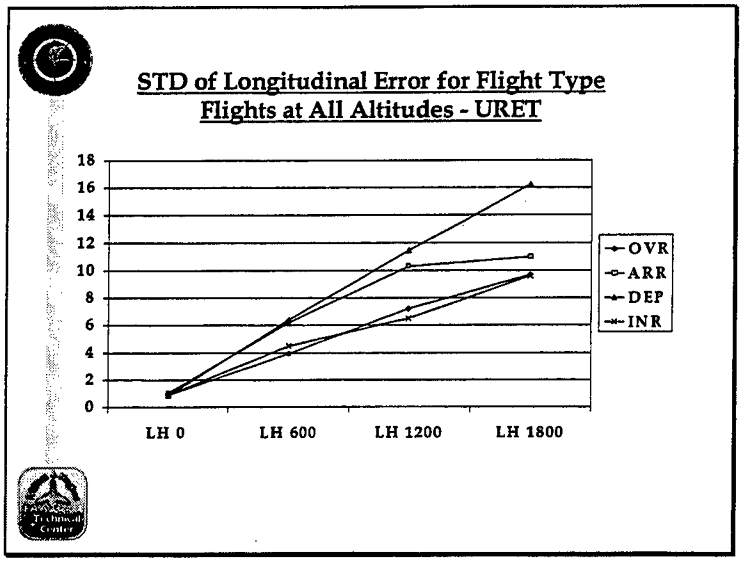
x_i is a data point
$\bar{x}$ is the sample mean
n is the sample size

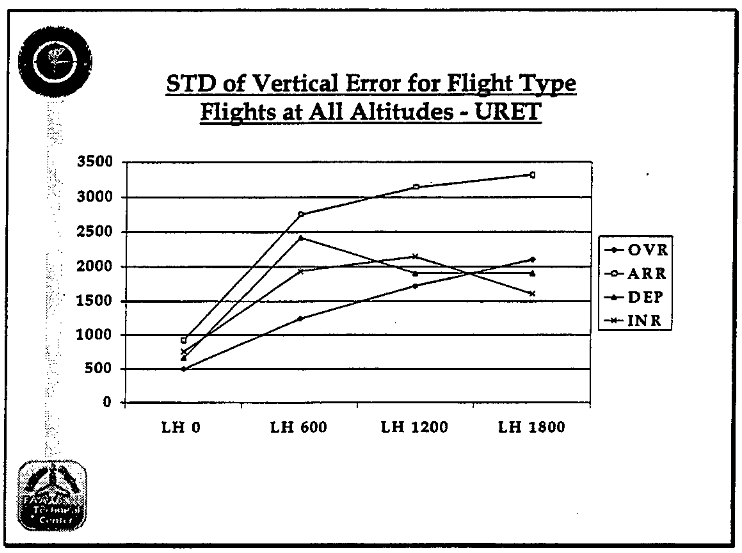
B.1 URET PowerPoint Slides for Standard Deviation

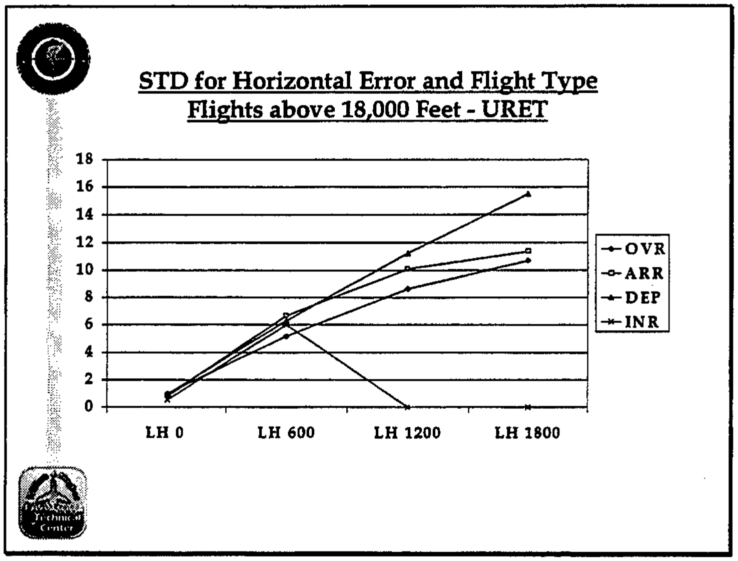
B.1.1 Flight Type

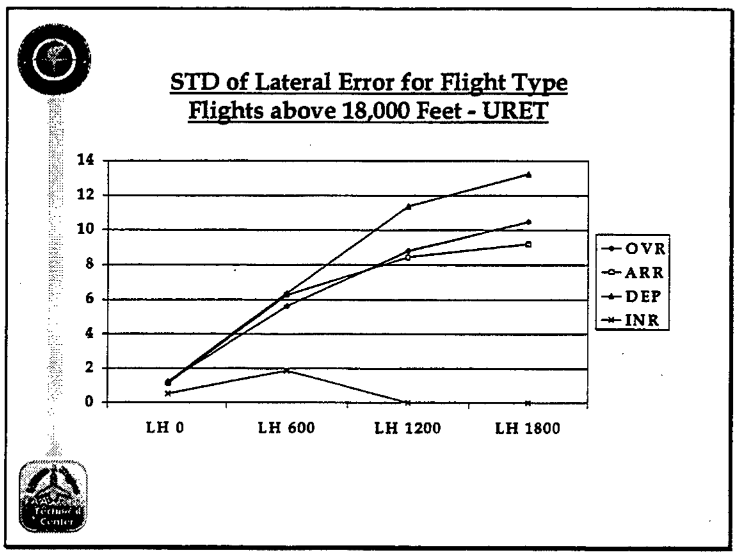


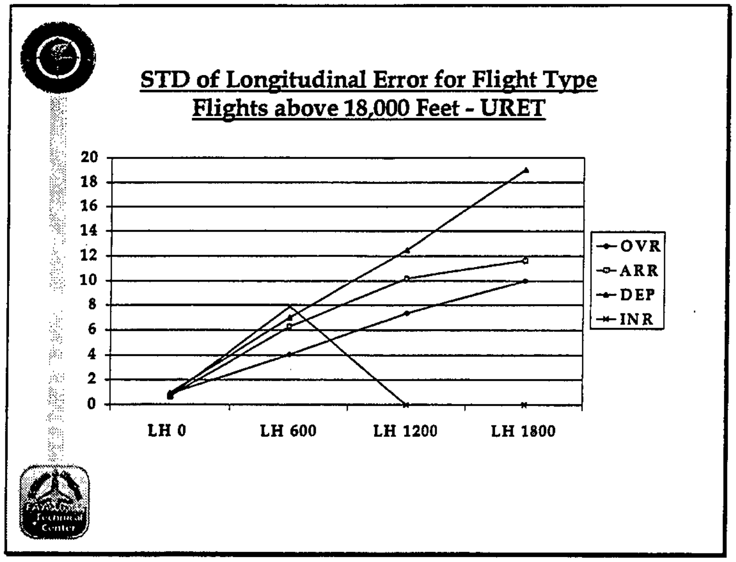


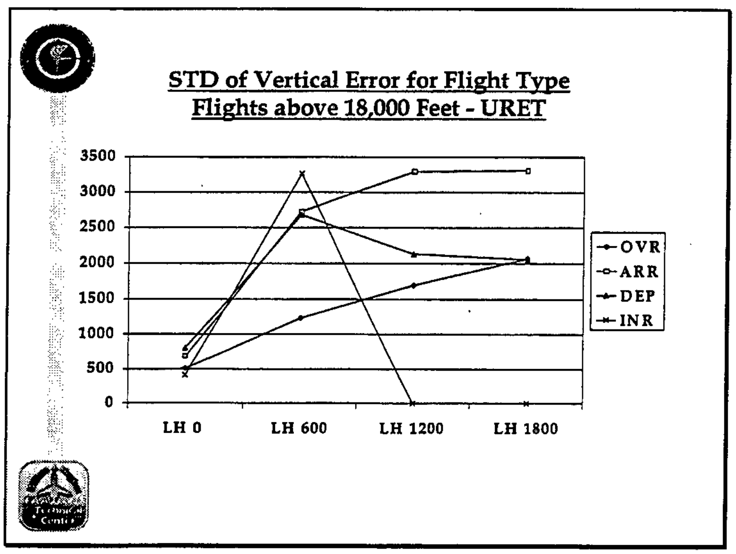

STD of Longitudinal Error for Flight Type
Flights at All Altitudes - URET
18
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR


STD of Vertical Error for Flight Type
Flights at All Altitudes - URET
3500
3000
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

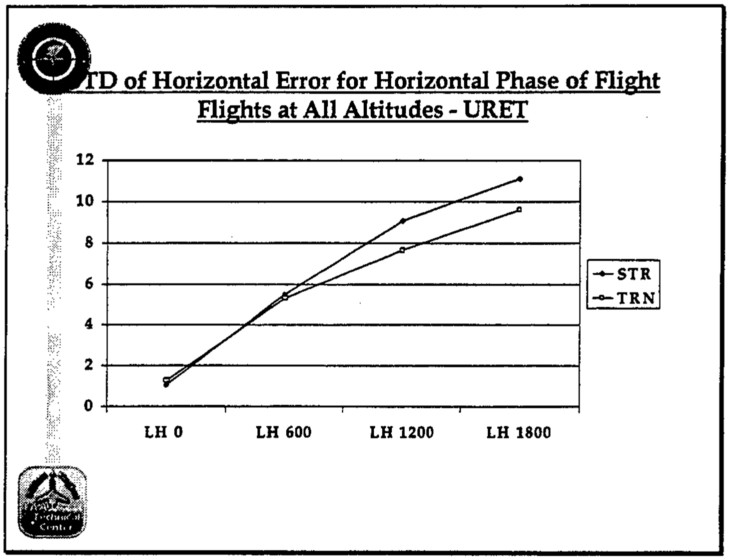

STD for Horizontal Error and Flight Type
Flights above 18,000 Feet - URET
18
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

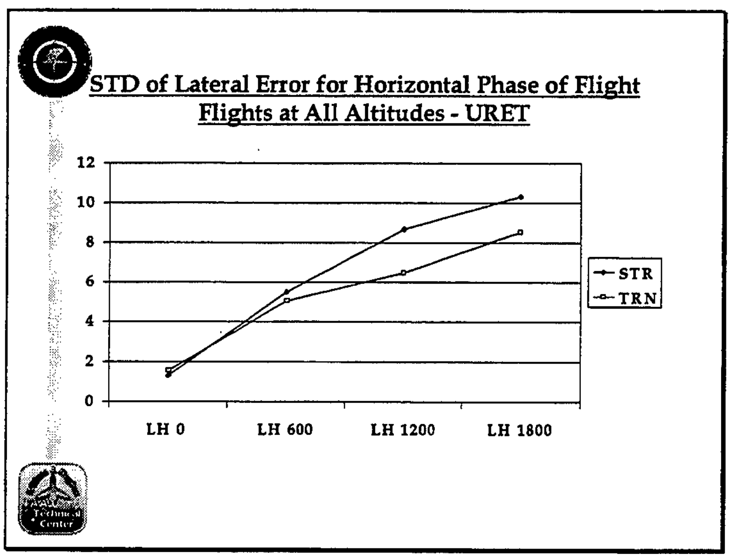

STD of Lateral Error for Flight Type
Flights above 18,000 Feet - URET
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

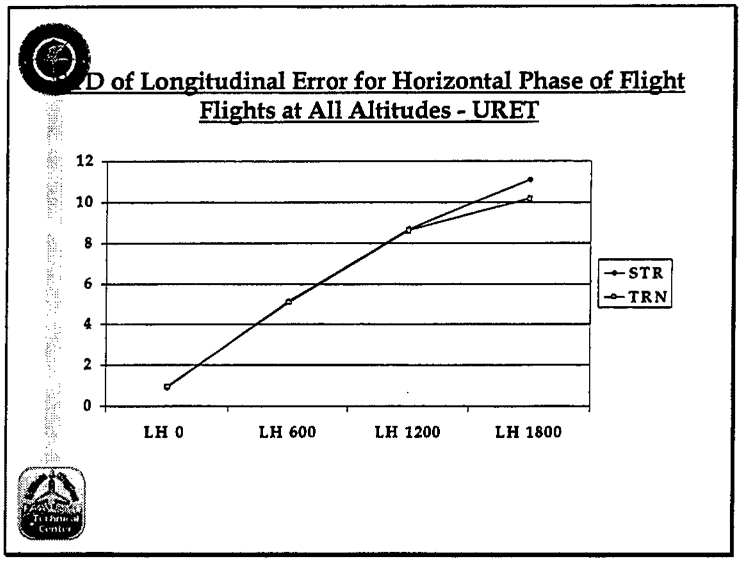

STD of Longitudinal Error for Flight Type
Flights above 18,000 Feet - URET
20
18
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

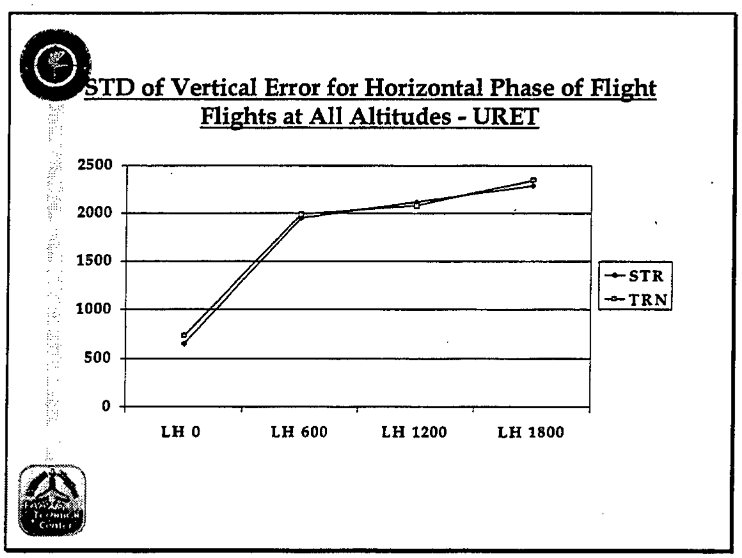

STD of Vertical Error for Flight Type
Flights above 18,000 Feet - URET
3500
3000
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

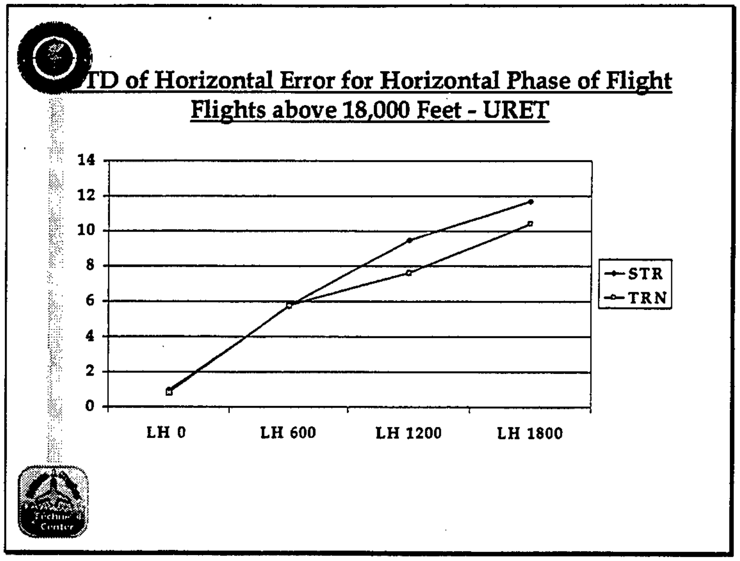
B.1.2 Horizontal Phase of Flight

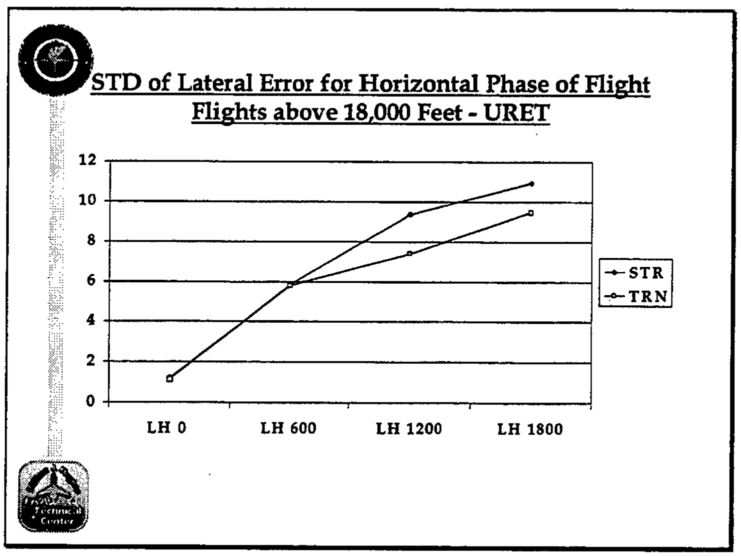


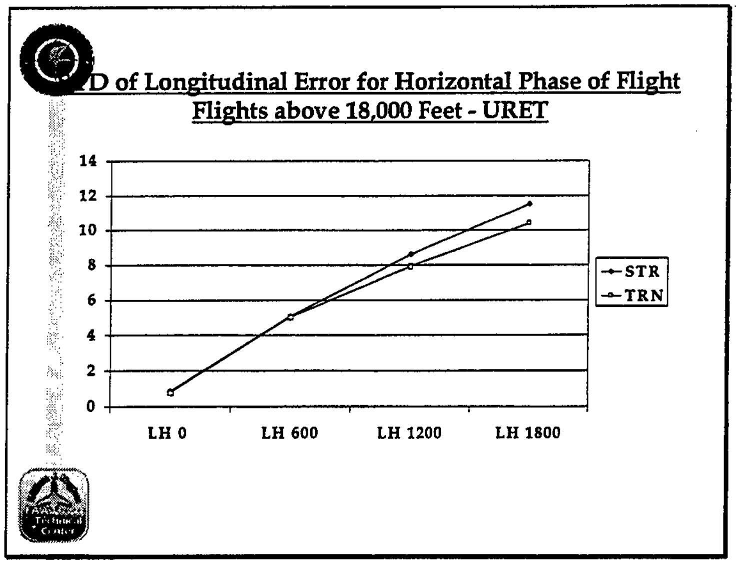



D of Longitudinal Error for Horizontal Phase of Flight
Flights at All Altitudes - URET
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN
Technical Center

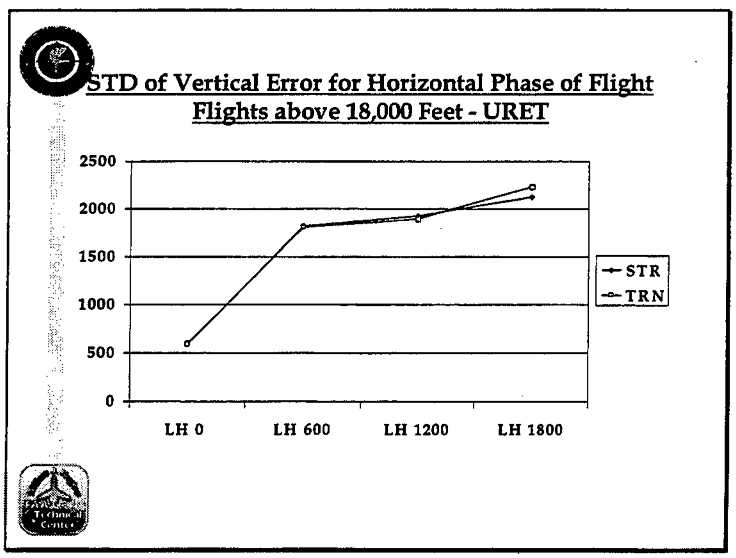

STD of Vertical Error for Horizontal Phase of Flight
Flights at All Altitudes - URET
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN
Technical Center


TD of Horizontal Error for Horizontal Phase of Flight
Flights above 18,000 Feet - URET
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN


STD of Lateral Error for Horizontal Phase of Flight
Flights above 18,000 Feet - URET
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN

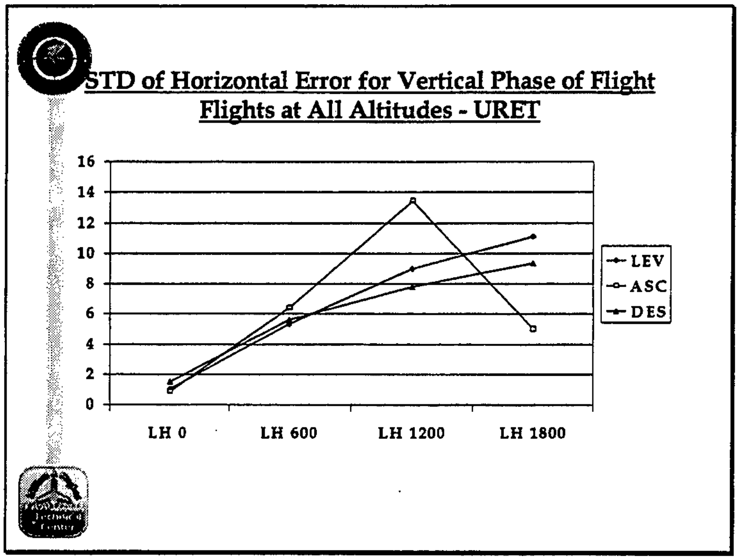


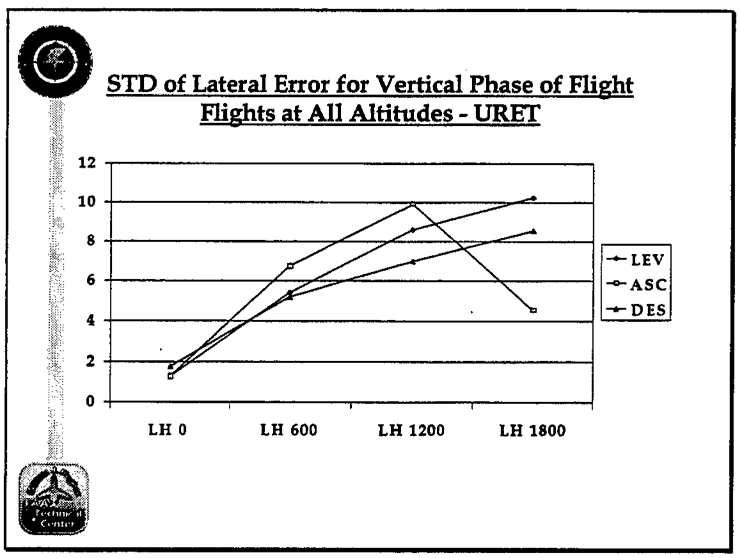
D of Longitudinal Error for Horizontal Phase of Flight
Flights above 18,000 Feet - URET
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN



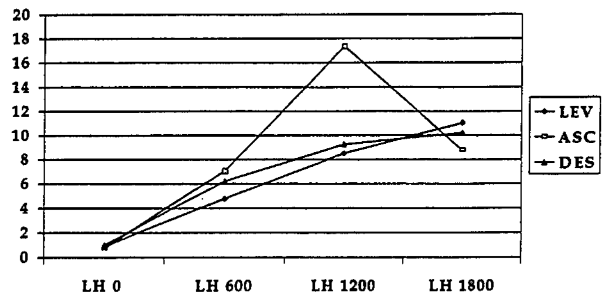
STD of Vertical Error for Horizontal Phase of Flight
Flights above 18,000 Feet - URET
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN

B.1.3 Vertical Phase of Flight

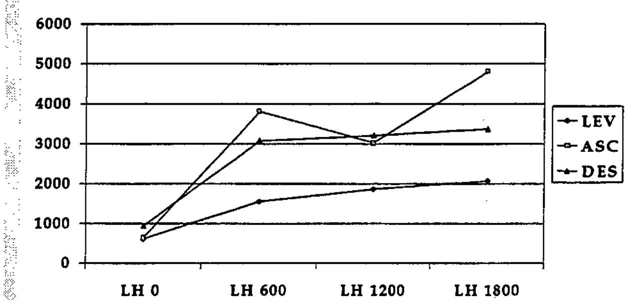


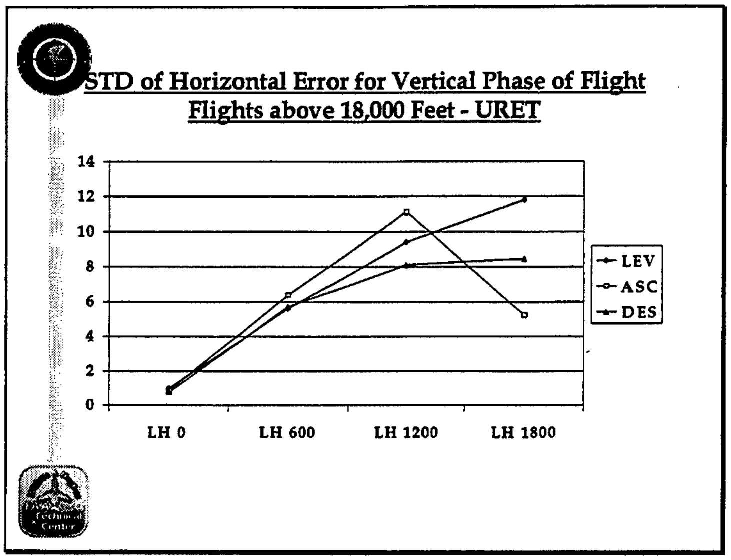


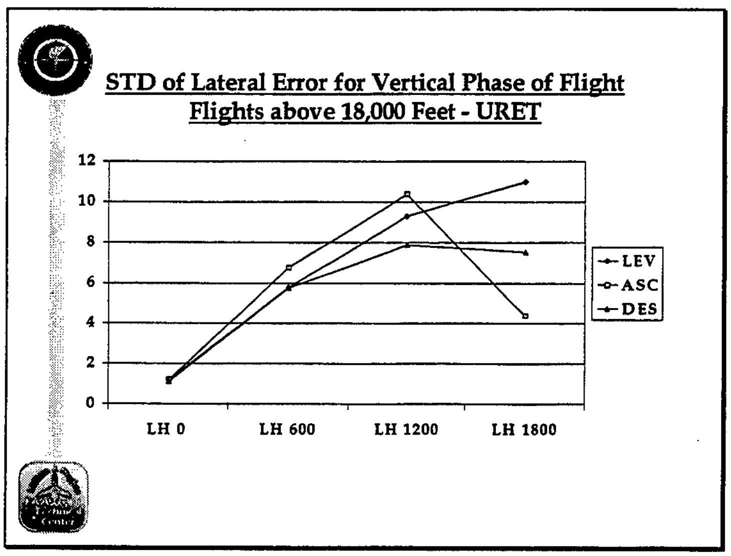
STD of Longitudinal Error for Vertical Phase of Flight
Flights at All Altitudes - URET



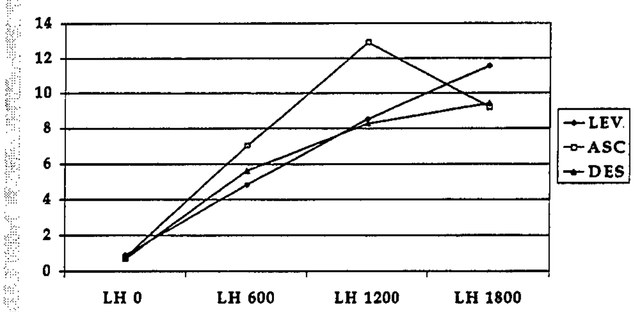
STD of Vertical Error for Vertical Phase of Flight
Flights at All Altitudes - URET



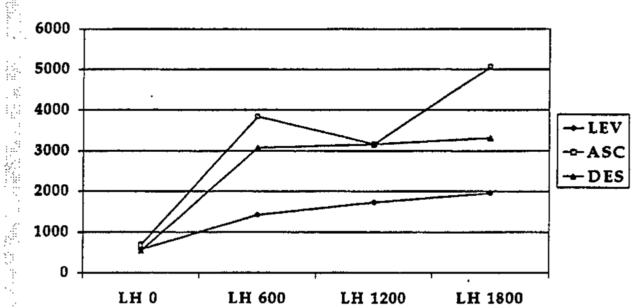

STD of Horizontal Error for Vertical Phase of Flight
Flights above 18,000 Feet - URET
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES


STD of Lateral Error for Vertical Phase of Flight
Flights above 18,000 Feet - URET
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES

STD of Longitudinal Error for Vertical Phase of Flight
Flights above 18,000 Feet - URET

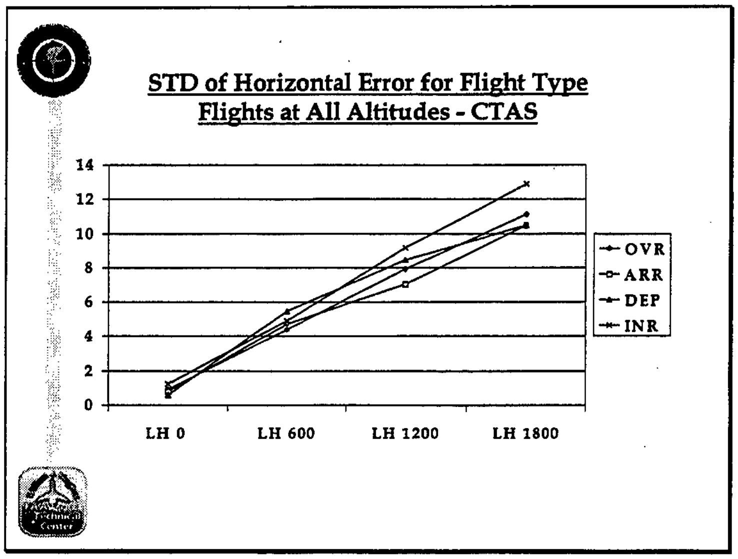


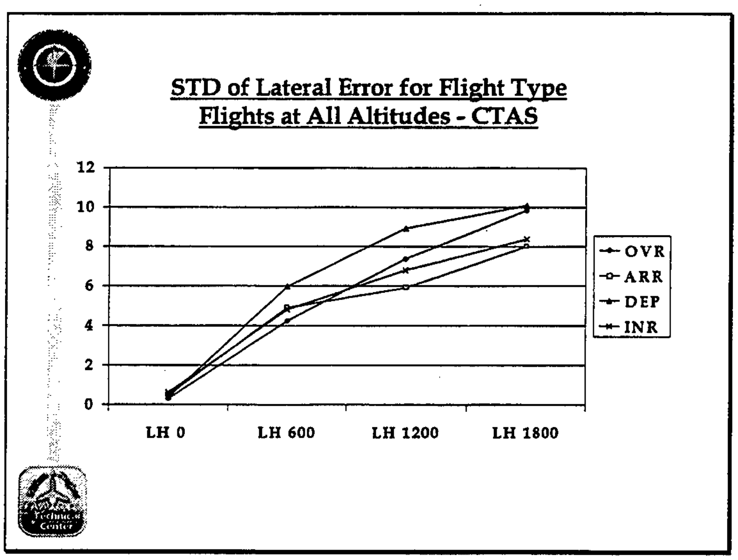
STD of Vertical Error for Vertical Phase of Flight
Flights above 18,000 Feet - URET

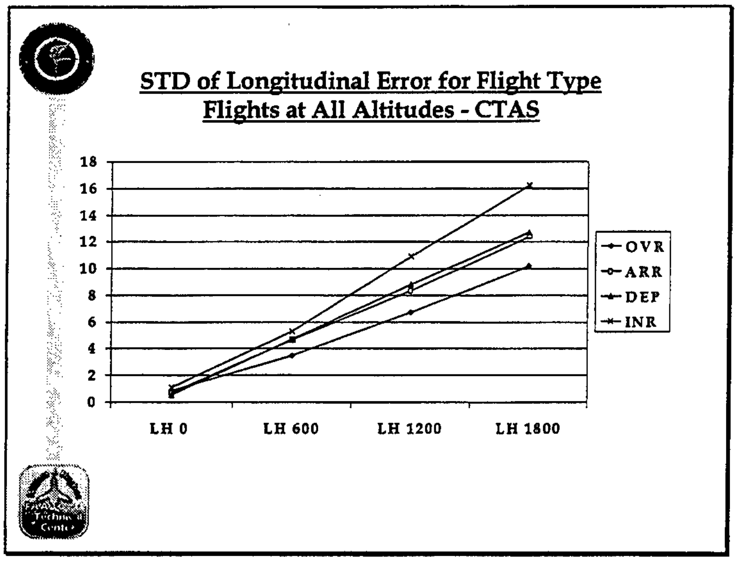


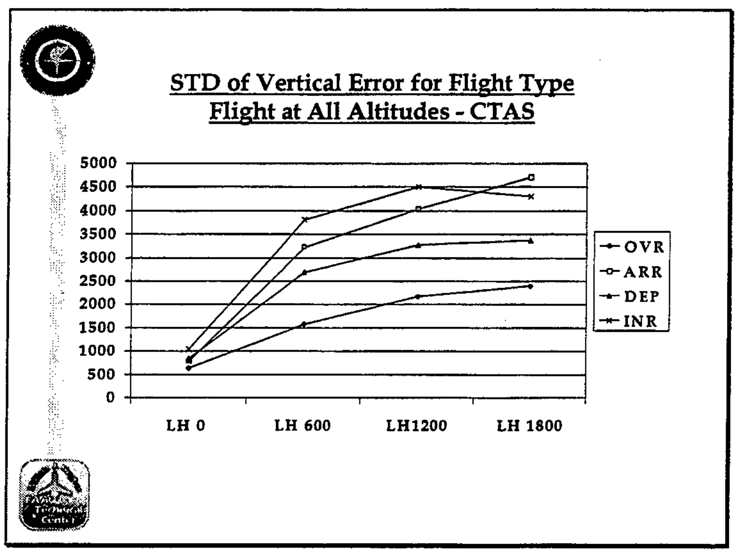
B.2 CTAS PowerPoint Slides for Standard Deviation

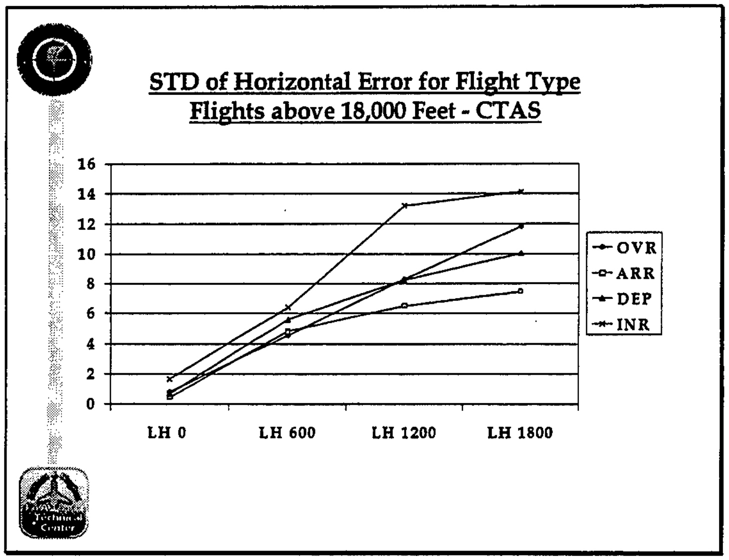
B.2.1. Flight Type

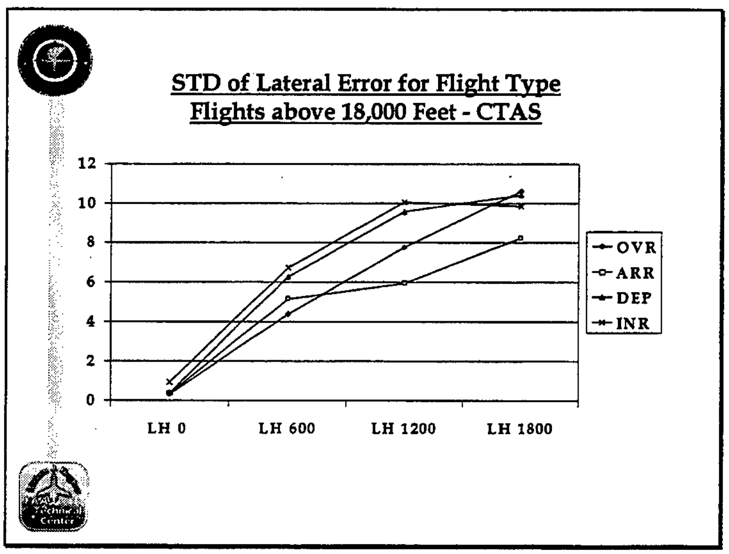


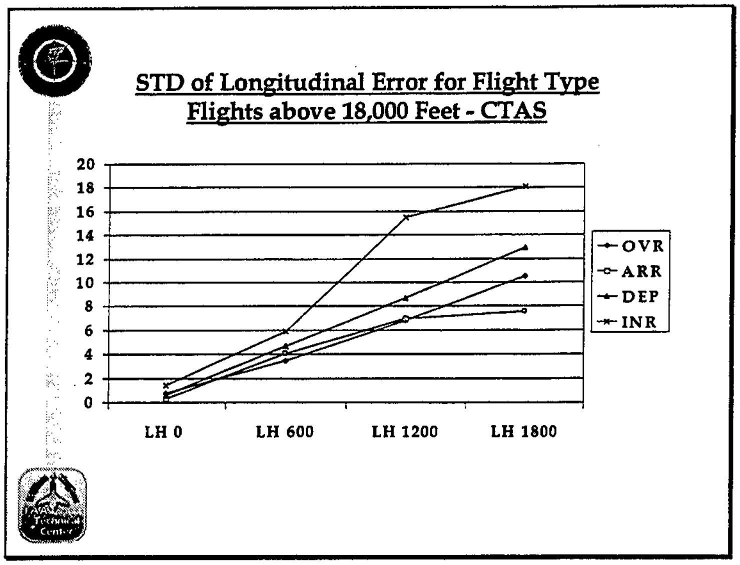


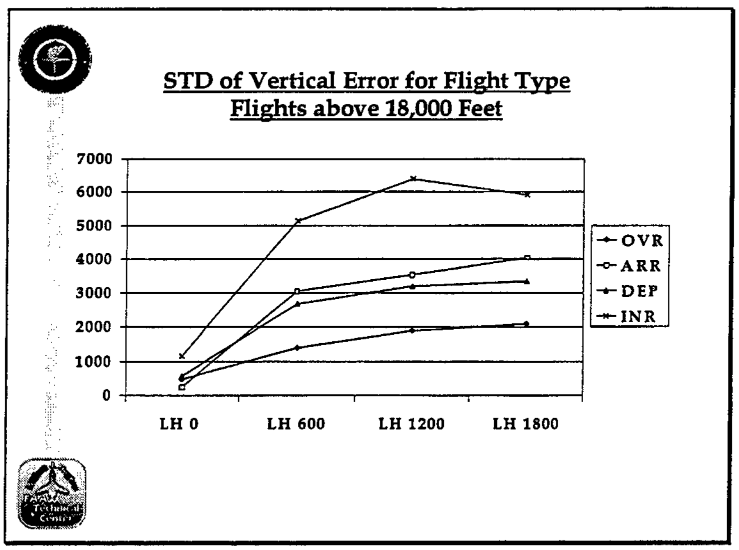

STD of Longitudinal Error for Flight Type
Flights at All Altitudes - CTAS
18
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR


STD of Vertical Error for Flight Type
Flight at All Altitudes - CTAS
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
LH 0
LH 600
LH1200
LH 1800
OVR
ARR
DEP
INR

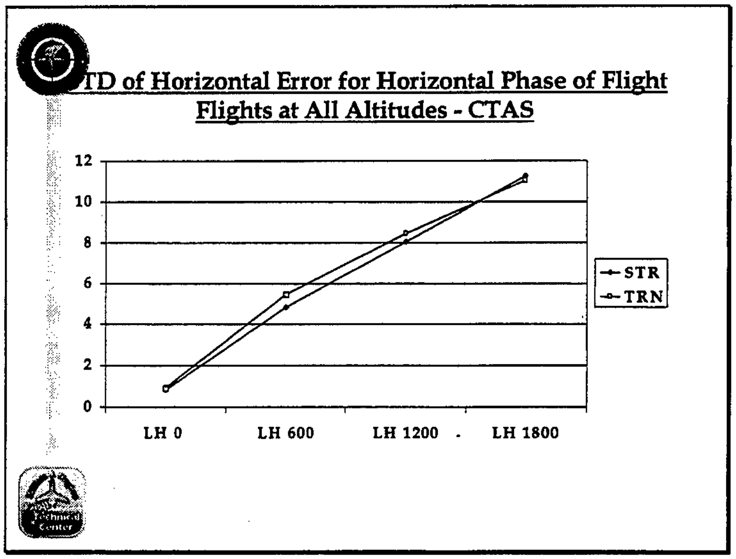

STD of Horizontal Error for Flight Type
Flights above 18,000 Feet - CTAS
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR
Technical Center

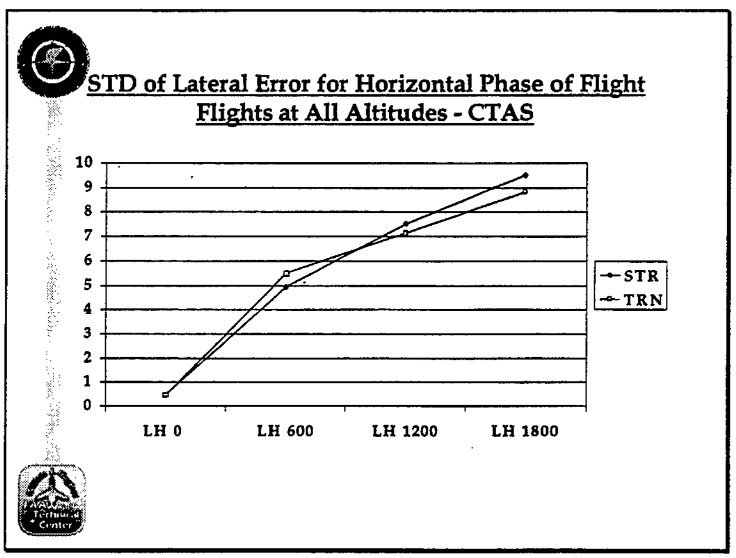

STD of Lateral Error for Flight Type
Flights above 18,000 Feet - CTAS
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR
Technical Center

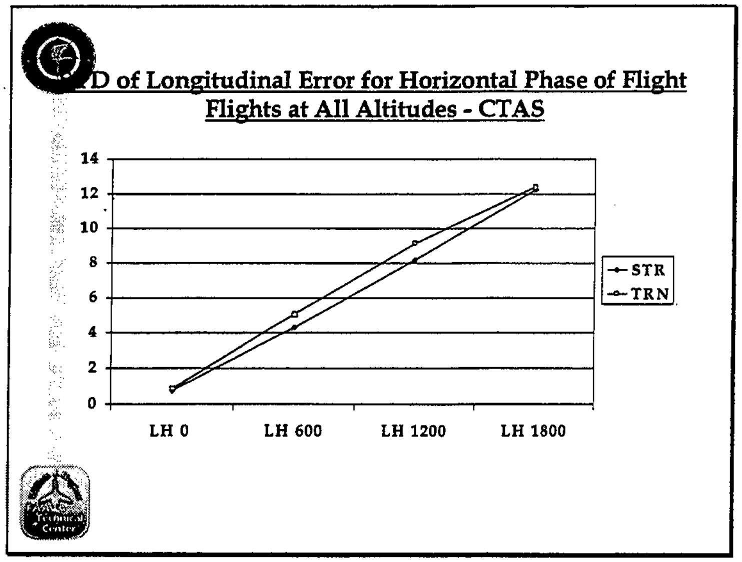

STD of Longitudinal Error for Flight Type
Flights above 18,000 Feet - CTAS
20
18
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

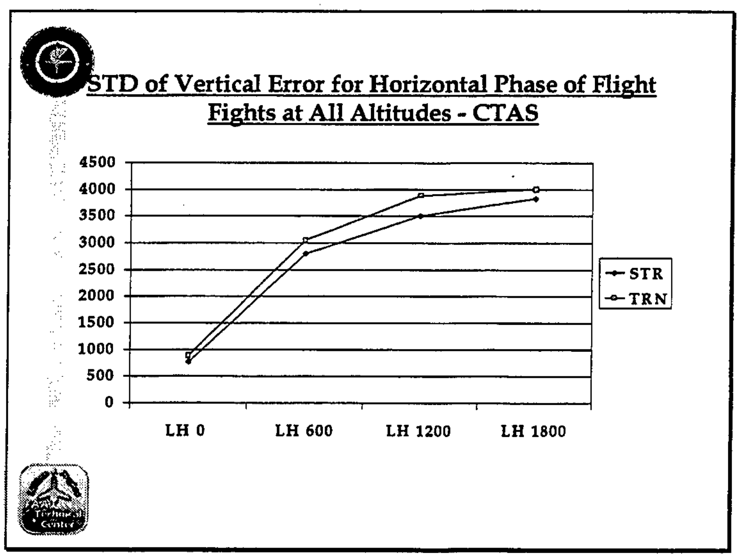

STD of Vertical Error for Flight Type
Flights above 18,000 Feet
7000
6000
5000
4000
3000
2000
1000
0
LH 0
LH 600
LH 1200
LH 1800
OVR
ARR
DEP
INR

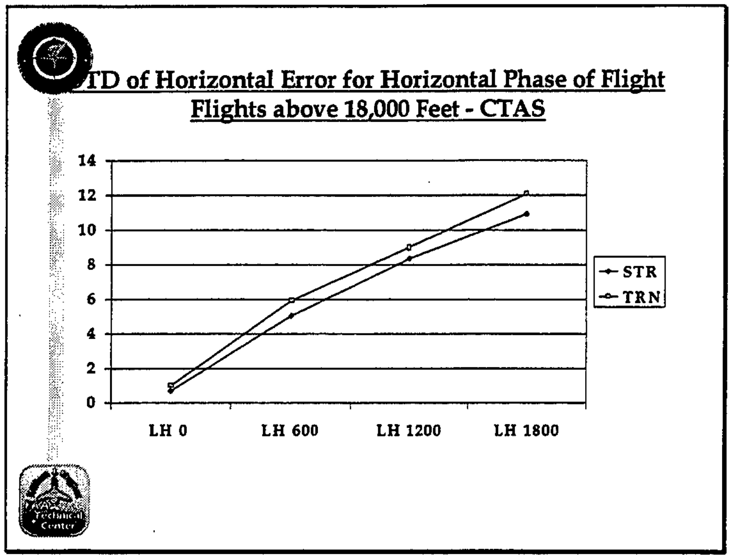
B.2.2. Horizontal Phase of Flight

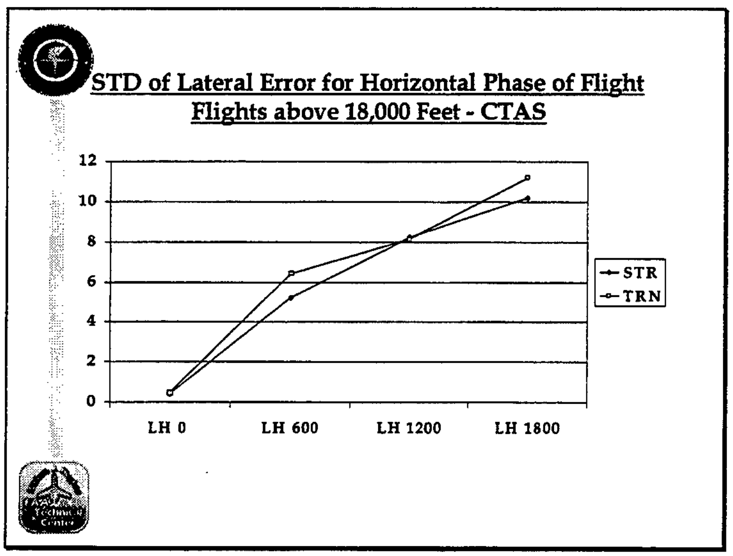


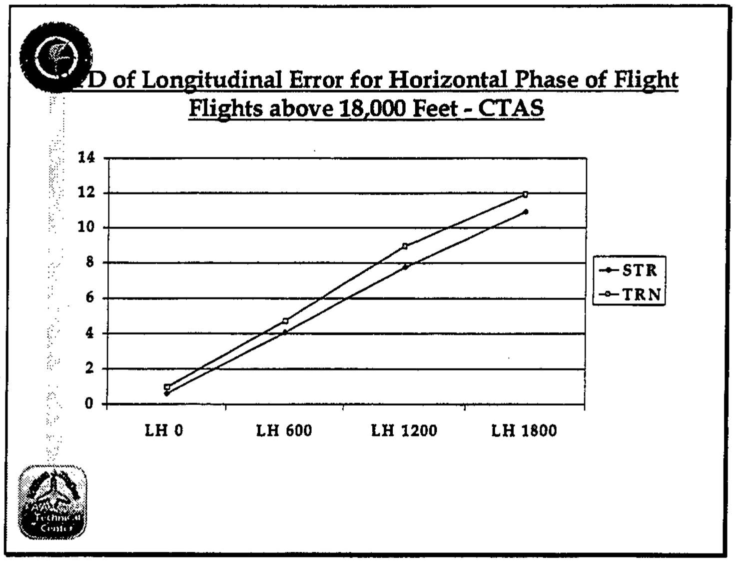


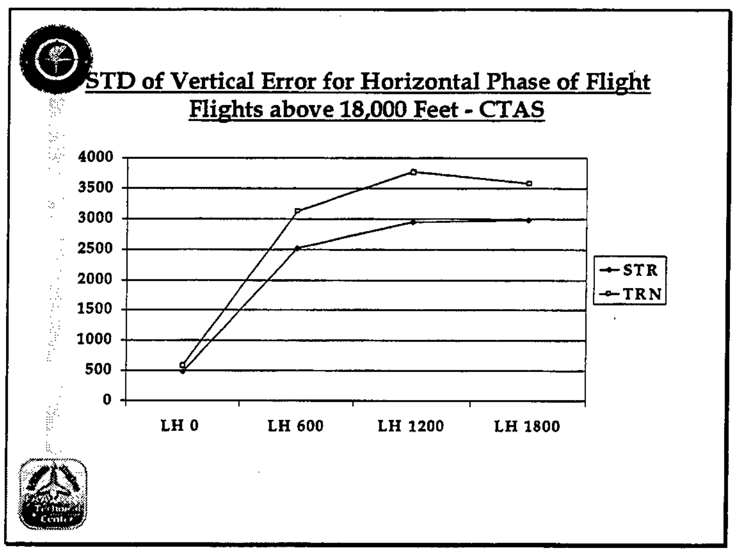

D of Longitudinal Error for Horizontal Phase of Flight
Flights at All Altitudes - CTAS
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN


STD of Vertical Error for Horizontal Phase of Flight
Fights at All Altitudes - CTAS
4500
4000
3500
3000
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN

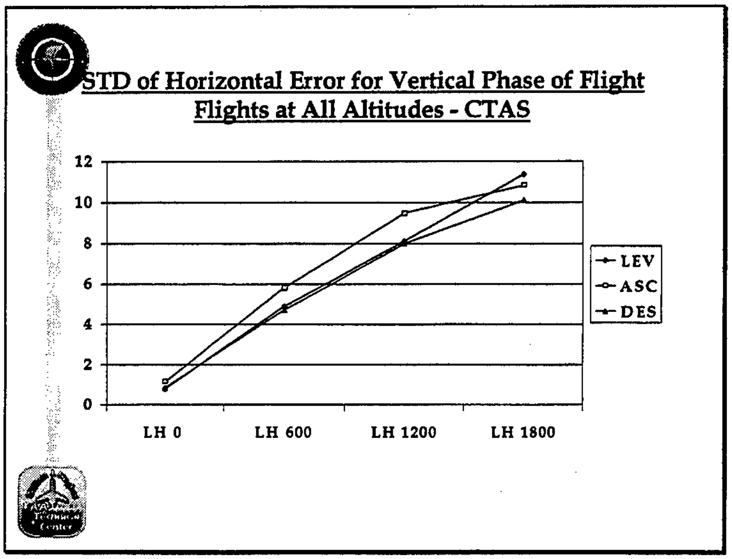

TD of Horizontal Error for Horizontal Phase of Flight
Flights above 18,000 Feet - CTAS
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN
Technical
Center

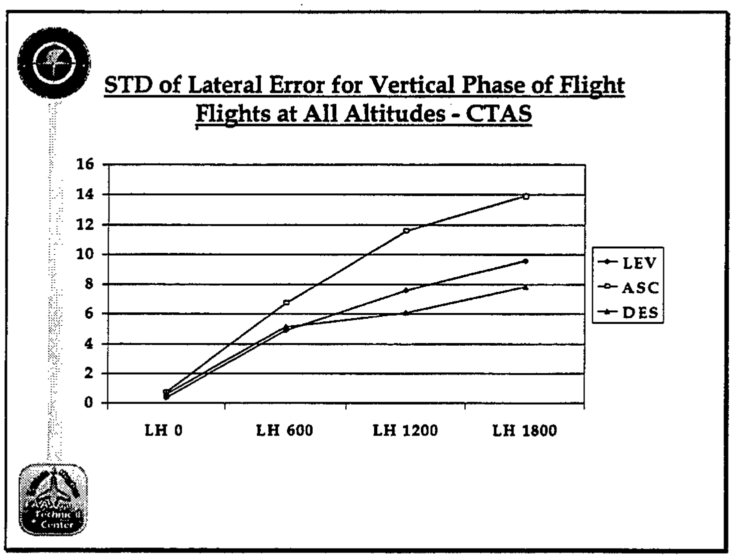

STD of Lateral Error for Horizontal Phase of Flight
Flights above 18,000 Feet - CTAS
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN
Technical
Center

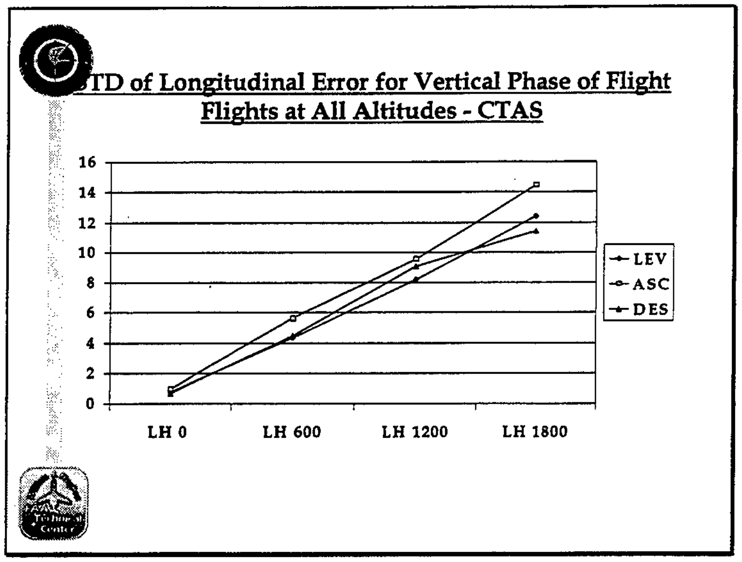

STD of Longitudinal Error for Horizontal Phase of Flight
Flights above 18,000 Feet - CTAS
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN

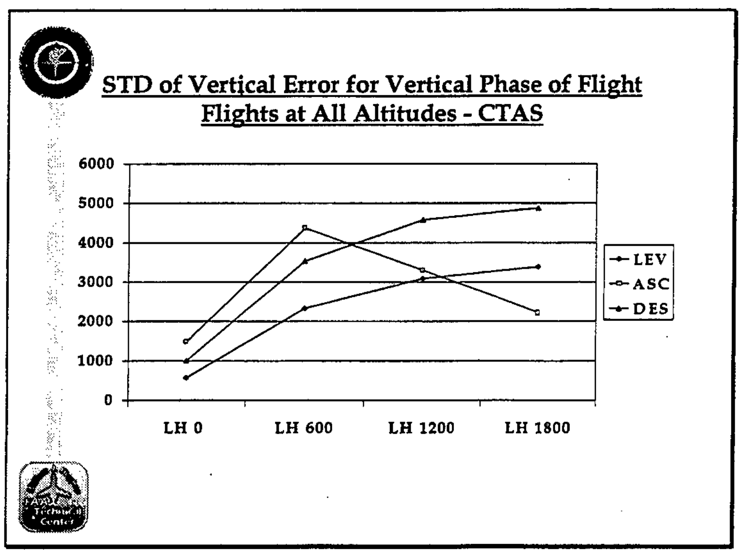

STD of Vertical Error for Horizontal Phase of Flight
Flights above 18,000 Feet - CTAS
4000
3500
3000
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
STR
TRN

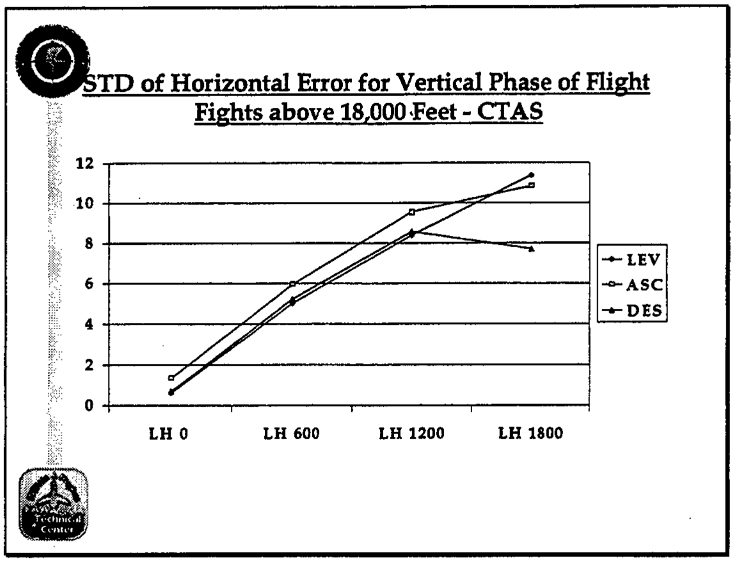
B.2.3. Vertical Phase of Flight

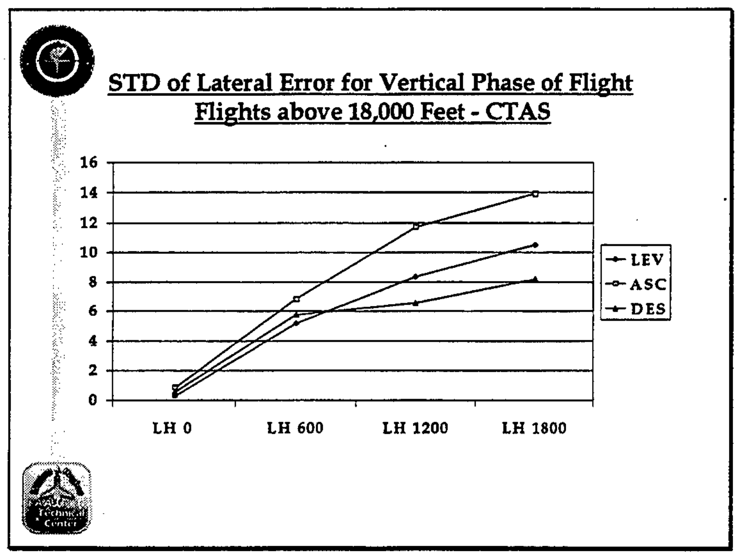





STD of Longitudinal Error for Vertical Phase of Flight
Flights at All Altitudes - CTAS
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES


STD of Vertical Error for Vertical Phase of Flight
Flights at All Altitudes - CTAS
6000
5000
4000
3000
2000
1000
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES


STD of Horizontal Error for Vertical Phase of Flight
Fights above 18,000 Feet - CTAS
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES


STD of Lateral Error for Vertical Phase of Flight
Flights above 18,000 Feet - CTAS
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14
12
10
8
6
4
2
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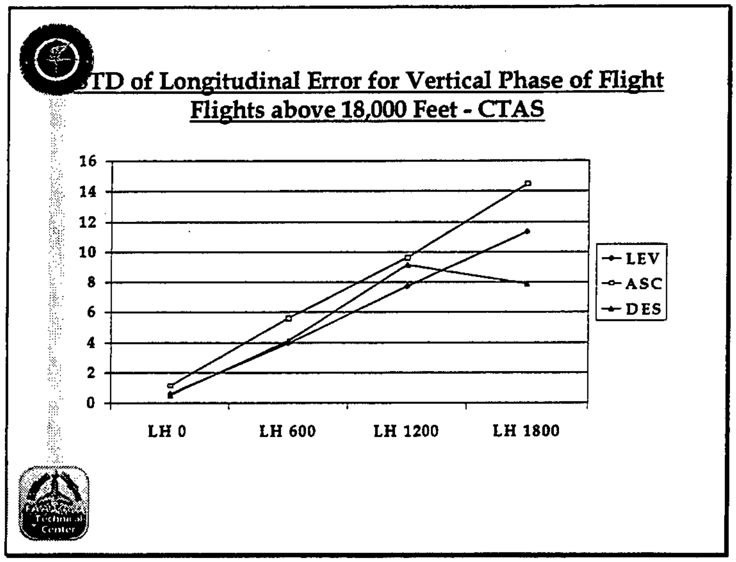
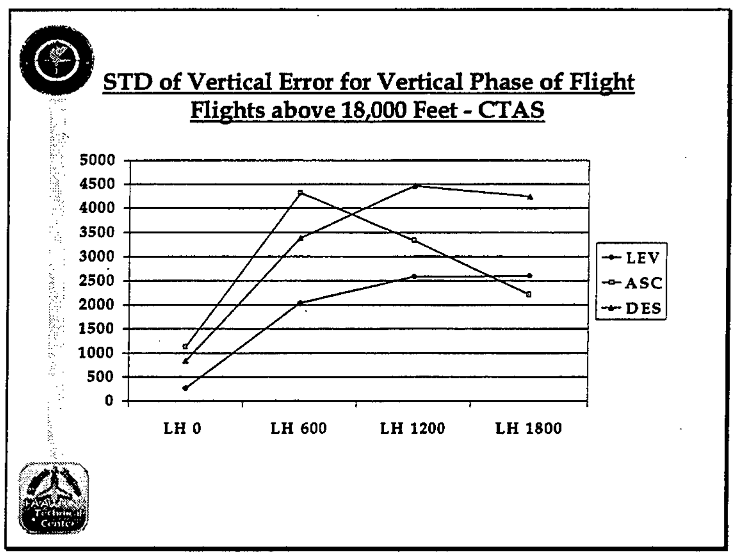
LH 1200
LH 1800
LEV
ASC
DES


STD of Longitudinal Error for Vertical Phase of Flight
Flights above 18,000 Feet - CTAS
16
14
12
10
8
6
4
2
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES
Technical
Center


STD of Vertical Error for Vertical Phase of Flight
Flights above 18,000 Feet - CTAS
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
LH 0
LH 600
LH 1200
LH 1800
LEV
ASC
DES
Technical
Center

Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/ Center-TRACON Automation System (CTAS)

APPENDIX C: Additional Flight Observations

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May 1999

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APPENDIX C

C.0 Introduction to Appendix

This Appendix is a supplement to *Trajectory Prediction Accuracy Report: User Request Evaluation Tool (URET)/Center-TRACON Automation System (CTAS)*, FAA ACT-250, 1999. The Appendix contains observations of four anomalous flights (two URET and two CTAS). These flights were selected for detailed study because they exhibited large prediction errors. They were used to verify the software implementation of the methodology. They are included in this Appendix to help the reader understand the methodology. These examples are not necessarily common occurrences and they are not presented as being indicative of any algorithmic problems with either trajectory modeler.

C.1 URET Observations

C.1.1 URET2

This example, depicting a ZID overflight with adequate track data, provides an example of an aircraft with both large longitudinal errors and large lateral errors. These large prediction errors resulted because the predicted ground speed was in error for a period of time, the aircraft flew by a waypoint, and the trajectory was not updated.

The aircraft, an A320 airbus, overflew the ZID airspace after departing Detroit Metro bound for Cancun. Its flight plan shows that it planned to fly from the Waterville Ohio VORTAC (YWV) to the Rosewood Ohio VORTAC (ROD) to the Nashville VORTAC (BNA). The flight was picked up just north of the ZID airspace at 12:19:10 at Flight Level 277, climbing to Flight Level 350. The track data, which extends from 12:19:10 (44350 seconds) through 13:07:58 (47278 seconds), shows that it flew slightly to the west of that route. This can be seen in Figure C.1-1 which shows the interpolated track XY data and flight plan route. Figure C.1-2 shows the aircraft track altitude vs. time.

C.1.1.1 Track Data

The HCS track data required only one correction: the first report was deleted because it did not have an altitude value. All the other position reports passed the tests applied by RDTRACKS, with 245 HCS track reports remaining to be processed for this flight.

C.1.1.2 Trajectories

The entire track time line and the time line for the eight trajectories recovered for this aircraft are presented in Figure C.1-3. The time line for the track is labeled "Track". The time lines for the trajectories are labeled with the trajectory's build time. These eight trajectories consist of four trajectory pairs. The trajectories in each pair are separated by one second in time. Trajectories with the same build time occur occasionally in URET. This happens when output queues build up due to the low priority of URET's data recording process. As a result, trajectories that were actually built at slightly different times may be time stamped with the same build time. Whenever such a trajectory was encountered in this study, one second was added to the build time of that trajectory. The first four trajectories (those labeled 43414 through 44339) were built before the first track point (44350 seconds). The first sample time is 44390. The trajectory used for this sample time was the 44363 trajectory since it was the latest trajectory prior to the sample time. All subsequent sampling and metric calculations use this trajectory also because no more trajectories were generated by URET.

C.1.1.3 Metrics

As can be seen from Figure C.1-4, initially the track and the trajectory are fairly close. The trajectory routed the flight directly from its current radar position to the next en route waypoint, the Rosewood VORTAC (ROD). However, the aircraft did not proceed to this waypoint but flew by it. The flyby created lateral errors between the trajectory and the track. The aircraft, in bypassing the waypoint, flew directly to the next waypoint, Nashville (BNA). The trajectory predicted the aircraft would fly to this waypoint. The track and the trajectory converged at the Nashville waypoint. Thus, the lateral errors became less and less as the aircraft got closer and closer to the Nashville waypoint. The vertical profile predicted was fairly close to the vertical profile flown. This can be seen in Figure C.1-2.

Figure C.1-5 shows the specific error geometry for a sample time of 44750 and a look ahead time of zero. The aircraft was near the Rosewood VORTAC at this time. The points labeled A, B, and C correspond to the similarly labeled points in Figure 2.5-3 in the report. B is the trajectory point being compared to the track point A. C is the next point on the trajectory, and AD is the

perpendicular to the line BC extended. The lateral error is AD, 3.76 nm, the longitudinal error is BD, 1.54 nm. The sign convention used here is that an aircraft arriving earlier than expected represents a positive longitudinal error, and that a track to the right of the predicted path represents a positive lateral error.

The aircraft flew faster than predicted in the climb to cruising altitude. The trajectory predicted the aircraft would increase its ground speed from 330 knots at FL 280 to 378 knots at FL 350. The airbus actually flew faster: 390 knots at FL 280 and 385 knots at FL 350. A longitudinal error was accumulated during the climb. In level cruise the actual and predicted ground speeds were fairly close. However, the longitudinal error caused by the error in predicted ground speed during the climb persists because the trajectory was not updated.

Table C.1-1 presents the trajectory metrics calculated for this aircraft.

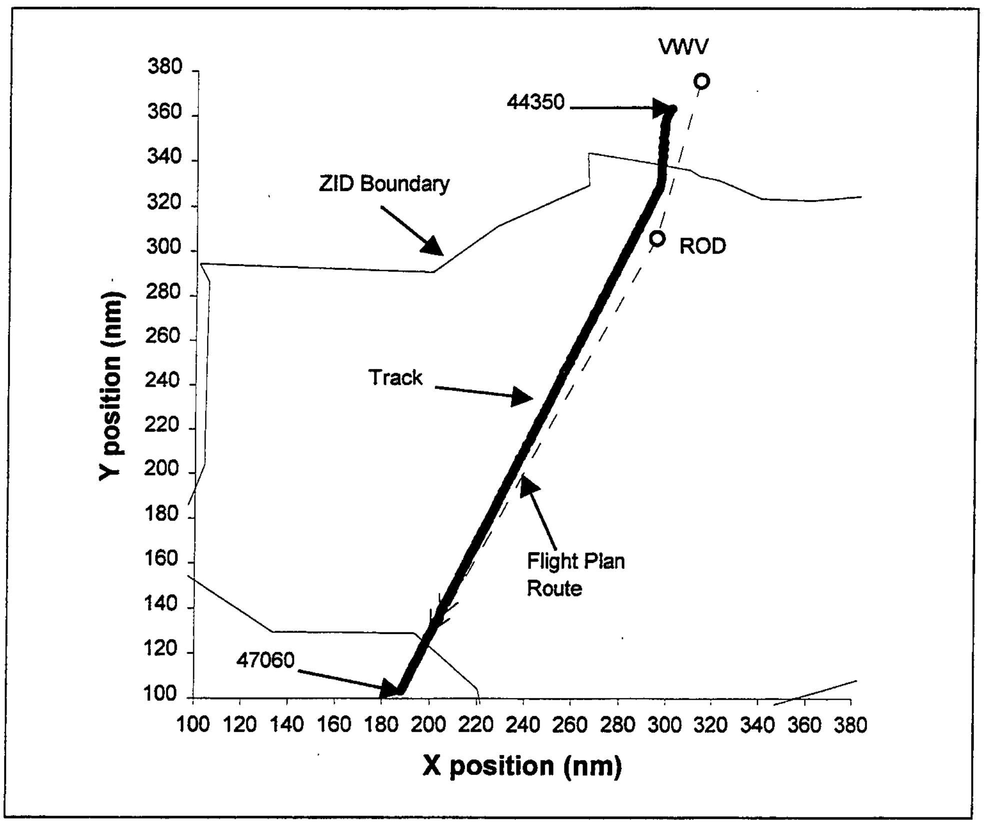

Figure C.1-1: Interpolated Track Position and Route

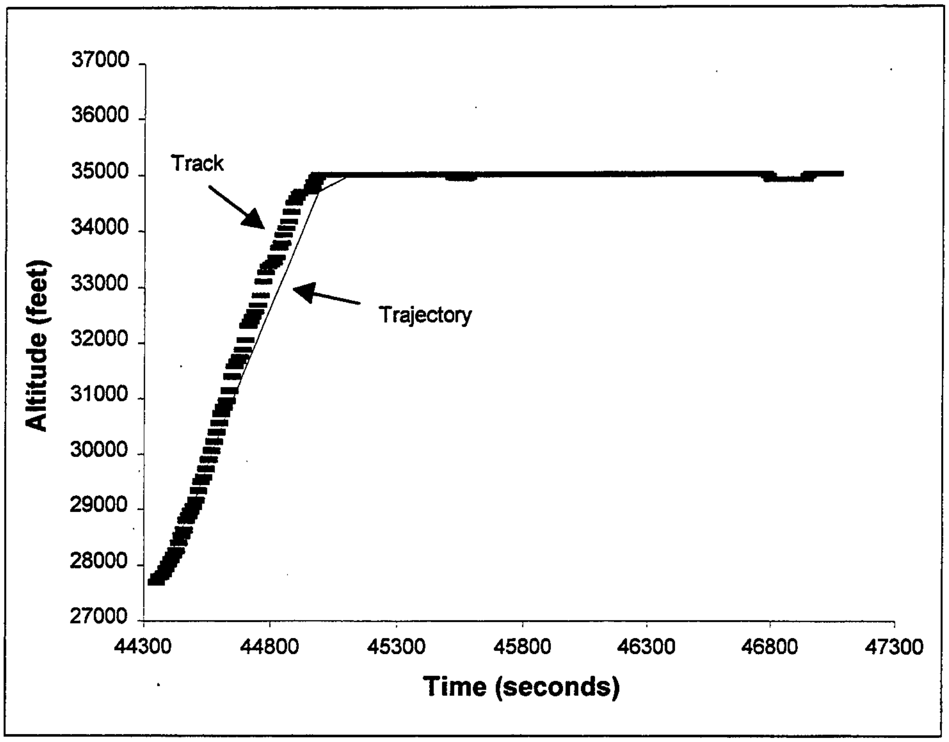

Figure C.1-2: Interpolated Track Altitude

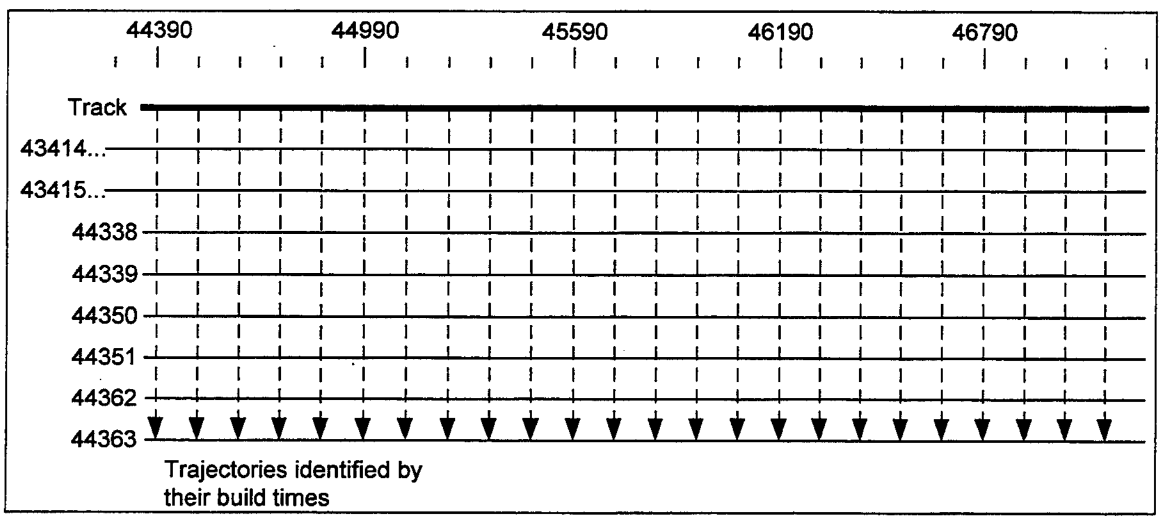

Figure C.1-3: Sampled Trajectories

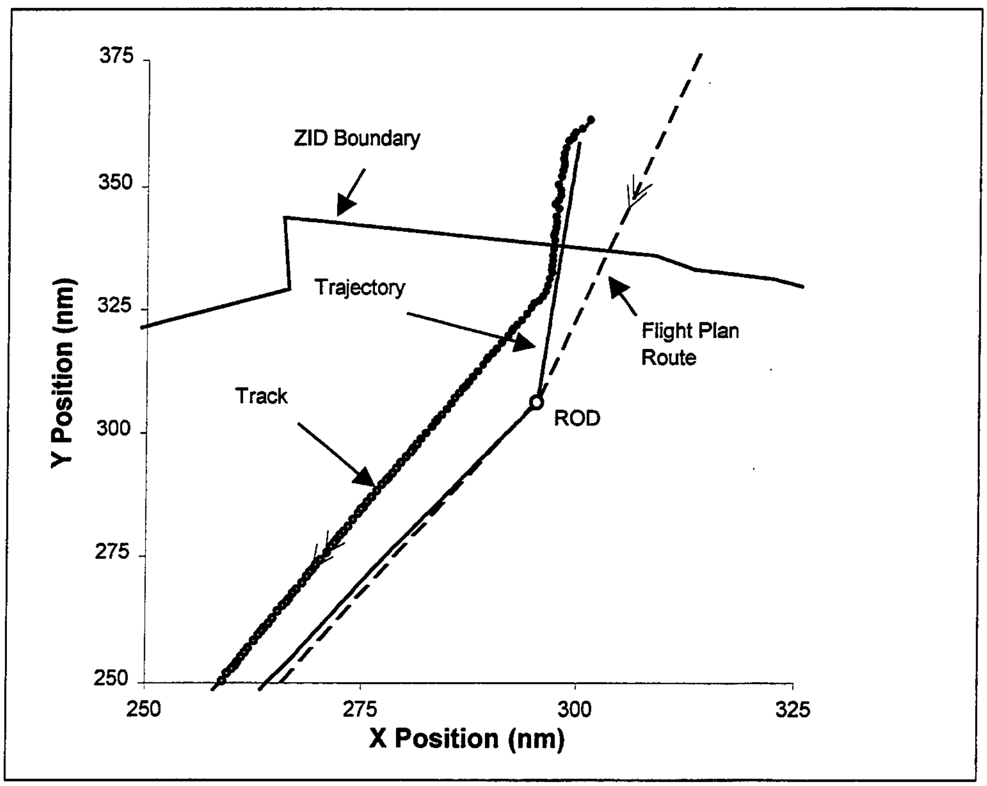

Figure C.1-4: Track XY and 44363 Trajectory

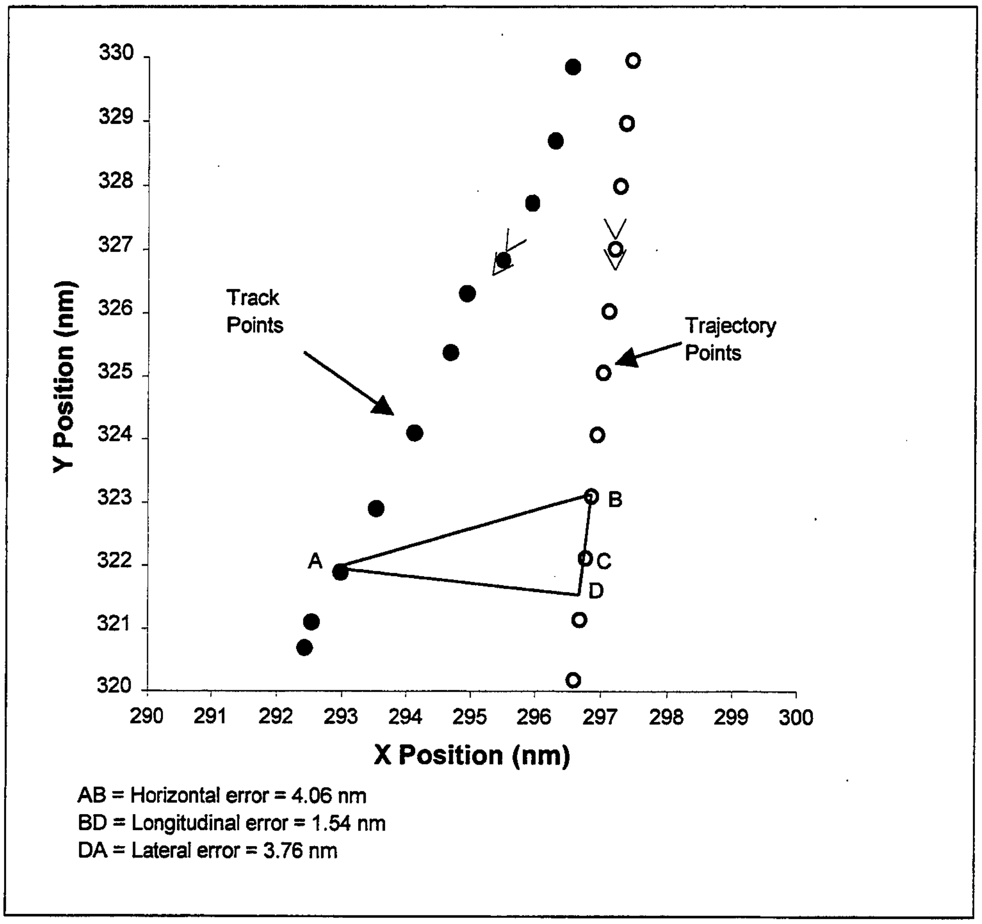

Figure C.1-5: XY Error Geometry at 44750, Look ahead = 0

Table C.1-1: Trajectory Metrics (1 of 3)[1]

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
44390	44363	0	-1.02	0.69	-67.00
		300	1.35	1.30	455.93
		600	6.78	8.17	293.11
		900	7.32	6.02	0.00
		1200	7.75	3.82	0.00
		1500	7.89	1.67	0.00
		1800	7.73	-0.28	0.00
44510	44363	0	-0.17	1.26	-23.46
		300	1.72	6.02	696.62
		600	7.44	7.39	0.00
		900	7.59	5.54	0.00
		1200	7.67	2.73	0.00
		1500	7.34	1.08	0.00
		1800	8.67	-1.09	0.00
44630	44363	0	1.03	0.73	259.11
		300	5.83	8.51	644.83
		600	7.29	6.28	0.00
		900	7.42	4.58	-67.00
		1200	7.86	1.64	0.00
		1500	7.64	0.20	0.00
		1800	9.03	-0.94	0.00
44750	44363	0	1.54	3.76	591.77
		300	7.24	7.71	0.00
		600	7.35	5.88	0.00
		900	7.57	3.36	0.00
		1200	7.14	1.41	0.00
		1500	8.55	-0.77	0.00
		1800	9.36	-0.99	0.00
44870	44363	0	1.86	8.32	773.20
		300	7.73	6.75	0.00
		600	7.28	5.18	0.00
		900	7.80	2.19	0.00
		1200	7.52	0.66	0.00
		1500	8.80	-0.91	0.00
		1800	8.82	-0.73	0.00

[1] In this chart, longitudinal and lateral error are reported in hundredths of nautical miles, and the vertical error is reported in hundredths of feet. The precision of the input HCS altitude data is reported to the nearest 100 feet, the apparent difference is simply an artifact of the track report processing.

Table C.1-1: Trajectory Metrics (2 of 3)

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
44990	44363	0	6.78	8.17	293.11
		300	7.32	6.02	0.00
		600	7.75	3.82	0.00
		900	7.89	1.67	0.00
		1200	7.73	-0.28	0.00
		1500	9.16	-0.99	0.00
		1800	9.46	-0.99	-33.00
45110	44363	0	7.44	7.39	0.00
		300	7.59	5.54	0.00
		600	7.67	2.73	0.00
		900	7.34	1.08	0.00
		1200	8.67	-1.09	0.00
		1500	9.49	-0.94	0.00
45230	44363	0	7.29	6.28	0.00
		300	7.42	4.58	-67.00
		600	7.86	1.64	0.00
		900	7.64	0.20	0.00
		1200	9.03	-0.94	0.00
		1500	9.30	-0.80	0.00
45350	44363	0	7.35	5.88	0.00
		300	7.57	3.36	0.00
		600	7.14	1.41	0.00
		900	8.55	-0.77	0.00
		1200	9.36	-0.99	0.00
45470	44363	0	7.28	5.18	0.00
		300	7.80	2.19	0.00
		600	7.52	0.66	0.00
		900	8.80	-0.91	0.00
		1200	8.82	-0.73	0.00
45590	44363	0	7.75	3.82	0.00
		300	7.89	1.67	0.00
		600	7.73	-0.28	0.00
		900	9.16	-0.99	0.00
		1200	9.46	-0.99	-33.00

Table C.1-1: Trajectory Metrics (3 of 3)

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
45710	44363	0	7.67	2.73	0.00
		300	7.34	1.08	0.00
		600	8.67	-1.09	0.00
		900	9.49	-0.94	0.00
45830	44363	0	7.86	1.64	0.00
		300	7.64	0.20	0.00
		600	9.03	-0.94	0.00
		900	9.30	-0.80	0.00
45950	44363	0	7.14	1.41	0.00
		300	8.55	-0.77	0.00
		600	9.36	-0.99	0.00
46070	44363	0	7.52	0.66	0.00
		300	8.80	-0.91	0.00
		600	8.82	-0.73	0.00
46190	44363	0	7.73	-0.28	0.00
		300	9.16	-0.99	0.00
46310	44363	0	8.67	-1.09	0.00
		300	9.49	-0.94	0.00
46430	44363	0	9.03	-0.94	0.00
		300	9.30	-0.80	0.00
46550	44363	0	9.36	-0.99	0.00
46670	44363	0	8.82	-0.73	0.00
46790	44363	0	9.46	-0.99	-33.00

C.1.2 URET3

This example shows how trajectory errors can be large when a trajectory modeler produces a single, erroneous trajectory, and how modeling instantaneous turns affects the trajectory metrics. This flight was a general aviation aircraft twin jet Gulfstream that departed Dulles Airport (IAD) and returned via the Youngstown Ohio (YNG) and Charleston West Virginia (HVQ) VORTACs. The interpolated XY track data and route are shown in Figure C.1-6. This is the eastern side of ZID. The radar track started in the Cleveland ARTCC (ZOB) at 15:01:22 (54082 seconds). The track data was interpolated each 10 seconds over the interval from 15:01:30 (54090 seconds) through 15:34:20 (56060 seconds), a duration of 1970 seconds or 32.8 minutes. The aircraft was in level flight at Flight Level 450 for most of this interval, making a 100 degree turn at the Charleston VORTAC to head back to Dulles.

C.1.2.1 Track Data

The HCS track data started with the aircraft in ZOB, at altitude approaching ZID, flying from the Youngstown VORTAC (YNG) to the Charleston VORTAC (HVG). The first two track reports had zero altitude and were discarded. There were 217 track reports. However, as the aircraft followed the Charleston transition to the Jasen1 STAR, the HCS lost altitude data when the aircraft was between the DILNN and FINKS fixes. After 15:34:22 there were no more altitude reports. The track was terminated at this point for analysis purposes. 166 reports remained to be used for analysis. During the period of no altitude data, the track was completely lost for 3408 seconds or 56.8 minutes. When the track was re-acquired, the ground speed was reported to be about 50 knots.

It was necessary to correct two of the 166 track reports by interpolation. The first was corrected because it reported the aircraft had not moved since its previous report. The second was corrected because it reported the aircraft was flying too slowly (270 knots) compared to its immediately previous speed of 417 knots.

C.1.2.2 Trajectories

Figure C.1-7 presents the trajectories generated for this aircraft. The individual trajectories are identified by their build times in seconds. The arrowheads are placed at two minute intervals and mark the sampling times. The three trajectories, built before the track started at 53134, 53303, and 54058 seconds, were not sampled. The trajectory used for the first sample (54130) was built at the time the track started (54082 seconds). This trajectory began at the approximate current position of the aircraft and predicted it would return directly to Dulles Airport (see Figure C.1-8).

Since another trajectory was not calculated until 336 seconds later at 54418 seconds, trajectory metrics were calculated for three sample times using this trajectory. The aircraft was still in ZOB at each of these sample times. Because the track and trajectory were diverging, large errors were found at each measurement. The largest horizontal error at a look ahead time of zero seconds was 42.4 nautical miles at a sample time of 54370 seconds. In addition, the trajectory descended the aircraft as it got closer to the airport. Because the aircraft was actually in level flight a vertical error of 2200 feet was incurred at the last measurement on this trajectory (look ahead time of zero).

Four additional trajectories were used, for which there was close agreement between the actual track and the track predictions with one exception. This exception occurred at the Charleston VORTAC when the aircraft turned to return to Dulles and cut the inside of the corner (or flew by the waypoint). Since URET models instantaneous turns, the horizontal separation between track and trajectory exceeded four nautical miles. A sample was taken during the turn at 55330 seconds, which had a horizontal error of 2.2 nautical miles. Figure C.1-9 shows the actual

location of the aircraft, the predicted location of the aircraft, and the horizontal error for this measurement[2].

C.1.2.3 Metrics

Table C.1-2 presents the trajectory metrics calculated for this aircraft. The longitudinal and lateral errors are in nautical miles; the vertical errors are in feet. As discussed in Section 2.5.1, a sample is taken 40 seconds after the start of track and then repeated each two minutes until the track ends, the trajectory ends, or the track leaves the center. At each sample time the distance between the track and trajectory was calculated at the current time and at look ahead times of zero and at 300 second or five minute increments into the future; resulting in look ahead times of 300, 600, 900, 1200, 1500, and 1800 seconds. This flight exited ZID at 15:28:20 (55700 seconds). From the table it can be seen that as the aircraft approached the center boundary, the metrics for fewer and fewer look ahead times were calculated.

As stated earlier, large errors are present at the first three samples times (54130, 54250, and 54370 seconds) when the trajectory with a build time of 54082 seconds was used. The errors are more representative starting with the fourth sample (54490 seconds).

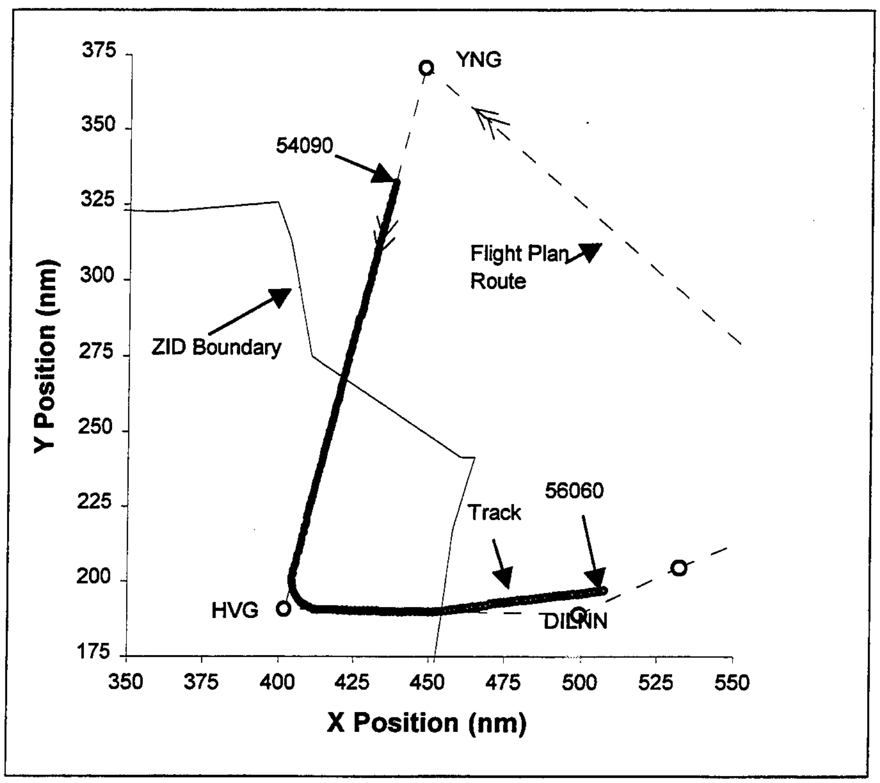

Figure C.1-6: Interpolated Track and Route XY Position

[2] The longitudinal error is normally the along track error, but for a short time just after a sharp turn the lateral error becomes the along track error.

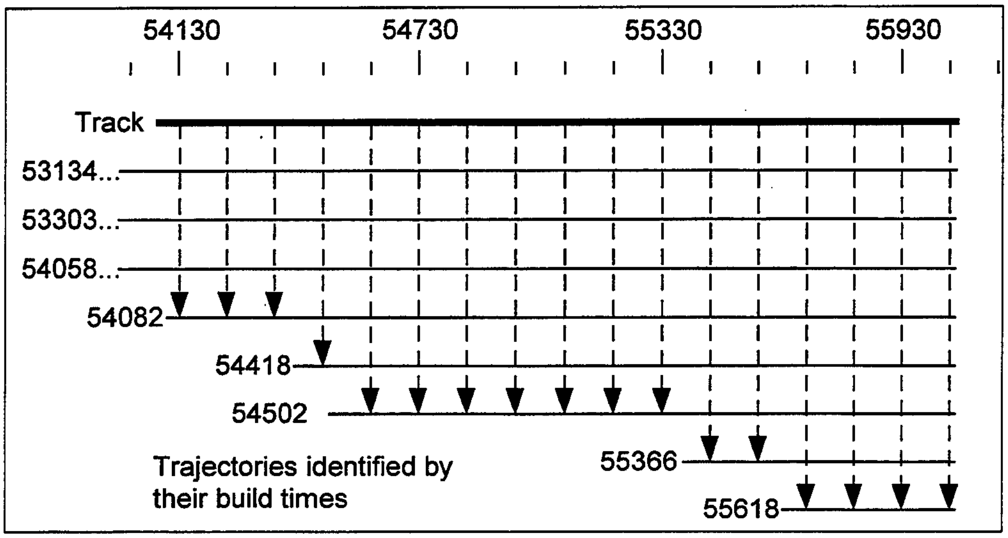

Figure C.1.7: Sampled Trajectories

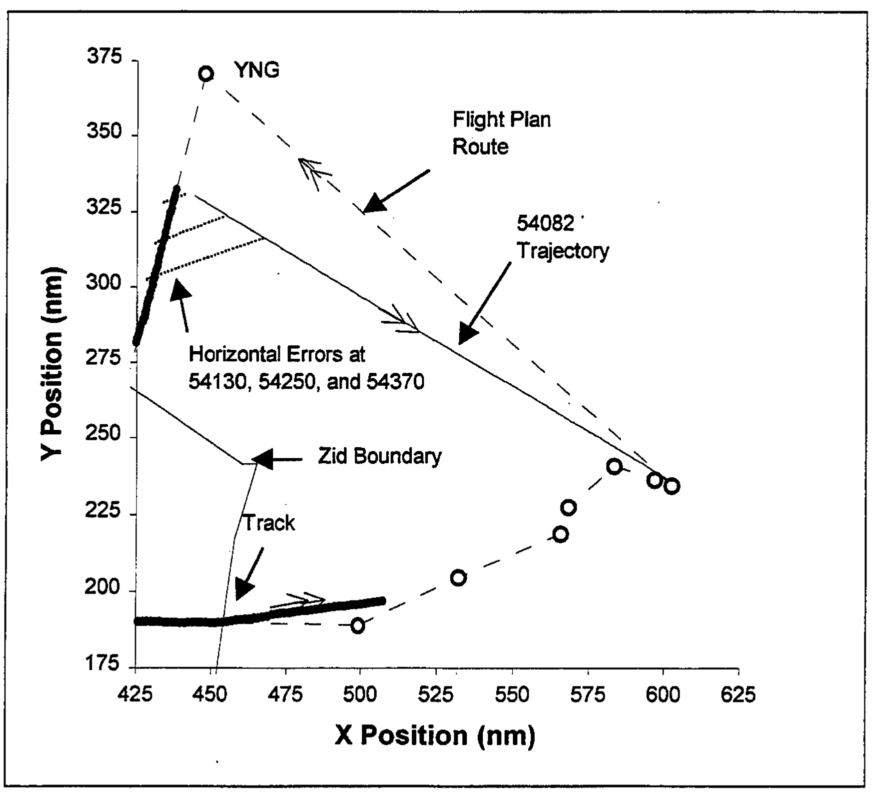

Figure C.1.8: Sampled Points Along 54082 Trajectory

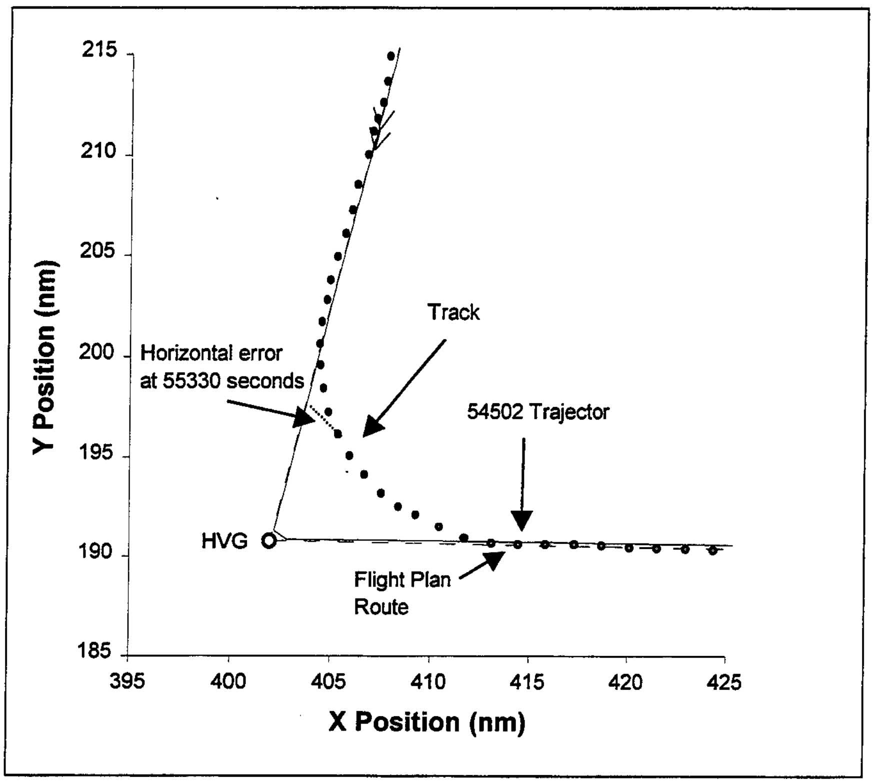

Figure C.1-9: Sampled Point During Turn

Table C.1-2: Trajectory Metrics

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
54130	54082	0	-4.14	7.19	0.00
		300	-32.58	38.93	3922.04
		600	-58.15	71.88	14420.54
		900	-84.79	103.76	22300.08
		1200	-109.33	134.87	32507.66
		1500	-99.82	120.34	38907.87
54250	54082	0	-16.18	19.99	0.00
		300	-42.87	52.50	8395.25
		600	-68.72	84.70	17631.89
		900	-95.77	115.83	25785.61
		1200	-107.08	132.88	35100.00
54370	54082	0	-27.53	32.23	2188.53
		300	-53.10	65.49	12376.71
		600	-79.36	97.45	20728.90
		900	-106.71	129.48	30746.50
		1200	-102.37	124.60	37473.73
54490	54418	0	1.67	0.19	0.00
		300	7.48	0.17	100.00
		600	12.63	0.38	0.00
		900	14.50	-7.99	0.00
		1200	36.58	0.22	100.00
54610	54502	0	0.37	0.15	100.00
		300	0.78	0.22	100.00
		600	0.38	0.11	100.00
		900	8.91	0.23	0.00
54730	54502	0	0.59	0.08	0.00
		300	0.84	0.26	0.00
		600	0.99	-1.93	100.00
		900	9.14	0.35	0.00
54850	54502	0	0.73	0.23	0.00
		300	0.31	0.06	0.00
		600	8.73	0.10	100.00
54970	54502	0	0.84	0.26	0.00
		300	1.31	0.26	0.00
		600	8.99	0.36	200.00
55090	54502	0	0.85	0.38	0.00
		300	6.85	-4.69	0.00
		600	9.68	0.17	1553.77
55210	54502	0	0.38	0.11	100.00
		300	8.91	0.23	0.00
55330	54502	0	0.99	-1.93	100.00
		300	9.14	0.35	0.00
55450	55366	0	-1.16	0.10	100.00
55570	55366	0	-0.75	0.36	200.00
55690	55618	0	0.14	-0.06	100.00

C.2 CTAS Observations

C.2.1 CTAS2

This example shows how trajectory errors can increase rapidly when updated trajectories are no longer available. In this example the aircraft flew faster than predicted. This resulted in large longitudinal errors when the trajectories were not updated. The lateral errors were minimal while the aircraft flew a straight line track, but a sharp turn on the SASIE SID caused a large lateral error briefly.

C.2.1.1 Track Data

The aircraft, a Piper Malibu, flew from the Beech factory in Wichita to the Addison airport near Dallas. The original Flight Plan routed the aircraft via the VORTACs at Pioneer (at Ponca City) (PER), Will Rogers (at Oklahoma City) (IRW), and Ardmore (ADM). Amendments rerouted the flight to the Bonham (BYP) VORTAC and the SASIE STAR, by passing the IRW and ADM VORTACs.

The aircraft was already at altitude (21,000 feet) when it was picked up by ZFW. The track data recovered for this aircraft began at 20:36:49 (74209 seconds) and ended at 21:37:13 (77833). This data was interpolated each ten seconds over the interval from 20:36:50 (74210 seconds) through 21:37:10 (77830 seconds), a duration of 3620 seconds, or approximately one hour. Figure C.2-1 presents a plot of the interpolated XY track data and Figure C.2-2 presents the interpolated altitude track data plotted against track time. This track began between the Pioneer and Will Rogers VORTACs in the Kansas City ARTCC (ZKC). Shortly after the start of the track, the Flight Plan was amended to fly to Addison Airport via the Bonham (BYP) VORTAC instead of the Will Rogers and Ardmore VORTACs. Also the aircraft was redirected to SASIE and never actually flew to BYP.

C.2.1.1.1 Time Adjustment

The time stamps assigned by the CTAS recording operation were first rounded to the nearest second and then adjusted by adding or subtracting seconds so the track reports all occurred at intervals of 12 seconds or at intervals of integer multiples of 12 seconds. Table C.2-1 shows the counts of the time intervals after rounding and before adjustment, after adjustment, and after correction processing. After the time adjustment there were 15 24-second intervals or 15 missing position reports. They were inserted by interpolation. There was one stationary point in the input data; it was replaced, also by interpolation.

C.2.1.2 Trajectories

Figure C.2-3 presents the track time line and the time lines for 15 of the 116 trajectories recovered for this aircraft. The time line is labeled "Track". Each of the trajectories is labeled with the trajectory's build time. The trajectory sampled for the starting sample time (74250 seconds) was the 74244 trajectory, since this was the latest trajectory prior to the sample time. The sampling interval used in this study was 120 seconds. The trajectory used for the next sample time (74250+120 = 74370 seconds) was the 74363 trajectory. This process of associating the last valid trajectory with a sample time was continued for the entire track. As a result 13 of the 116 trajectories were used: 74244, 74363, 74484, 74604, 74723, 74844, 74963, 75083, 75203, 75323, 75443, 75565, and 75647.

The first two trajectories follow the Flight Plan as it was originally filed to the Will Rogers VORTAC and then proceed to join the route from the current position to the Bonham VORTAC. Subsequent trajectories follow the Flight Plan as it was amended.

C.2.1.3 Metrics

The predictions, for a zero look ahead time, closely match the actual flight until the 75647 trajectory, which was the last trajectory CTAS provided. The predicted ground speed was about 50 knots less than the actual ground speed for each trajectory. As long as the trajectories kept getting updated, the position error for the zero look ahead time remains small. But as the track diverged longitudinally from the trajectory, as the trajectory got older, large longitudinal errors were calculated. Figure C.2-4 provides a plot of the values of the X coordinates of the track and the trajectory (the 75647 trajectory), and shows the X component of the horizontal error increasing with time. Similarly, Figure C.2-5 shows the Y component of the horizontal error increasing with time. These figures show the trajectory's XY data is accurate but displaced in time.

Figure C.2-6 is a plot of altitude vs time for the track and the trajectory. The predicted Top of Descent (TOD) is in error in all of the predicted trajectories by about 74 nautical miles. This causes large altitude errors in the descent phase of the flight.

Table C.2-2 presents the trajectory metrics calculated for this aircraft.

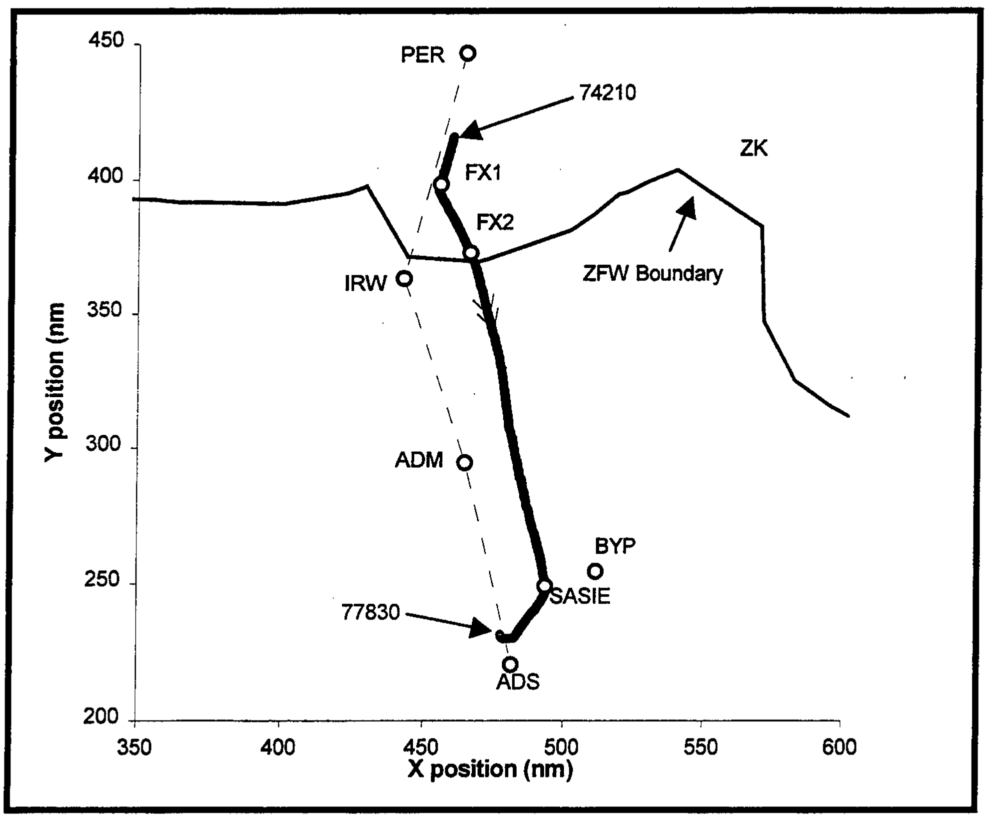

Figure C.2-1: Track XY Position

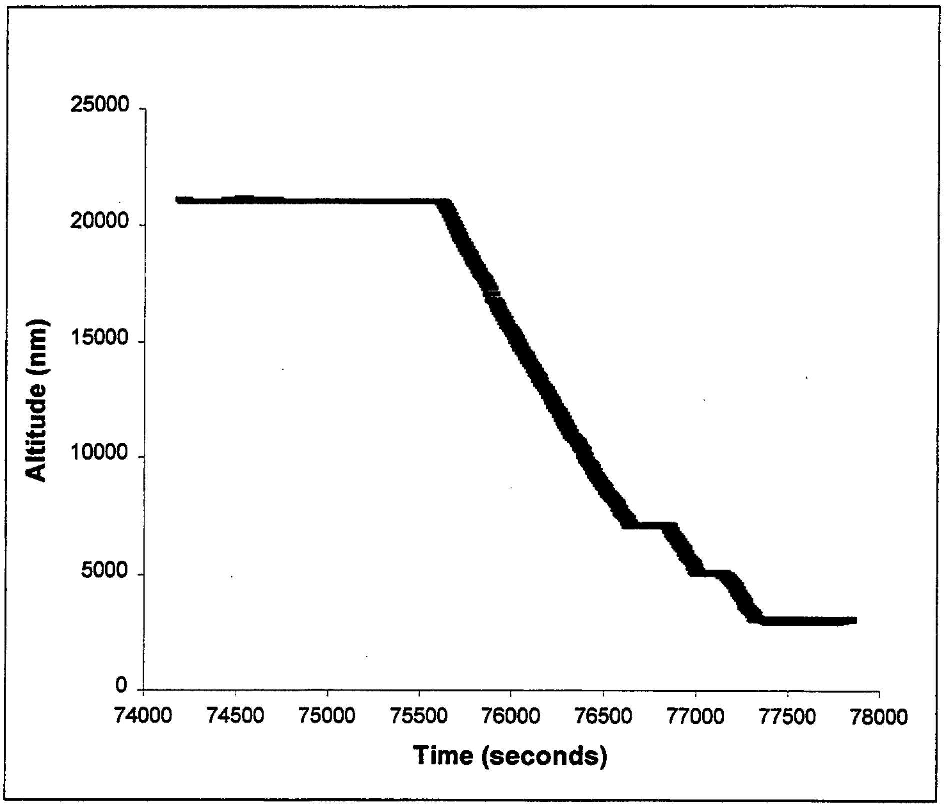

Figure C.2-2: Track Altitude

Table C.2-1: Track Report Time Intervals for CTAS 2

Gap Size (Seconds)	Count Before Adjustment	Count After Adjustment	Count After Processing
11	52	0	0
12	164	272	302
13	56	0	0
23	3	0	0
24	11	15	0
25	1	0	0

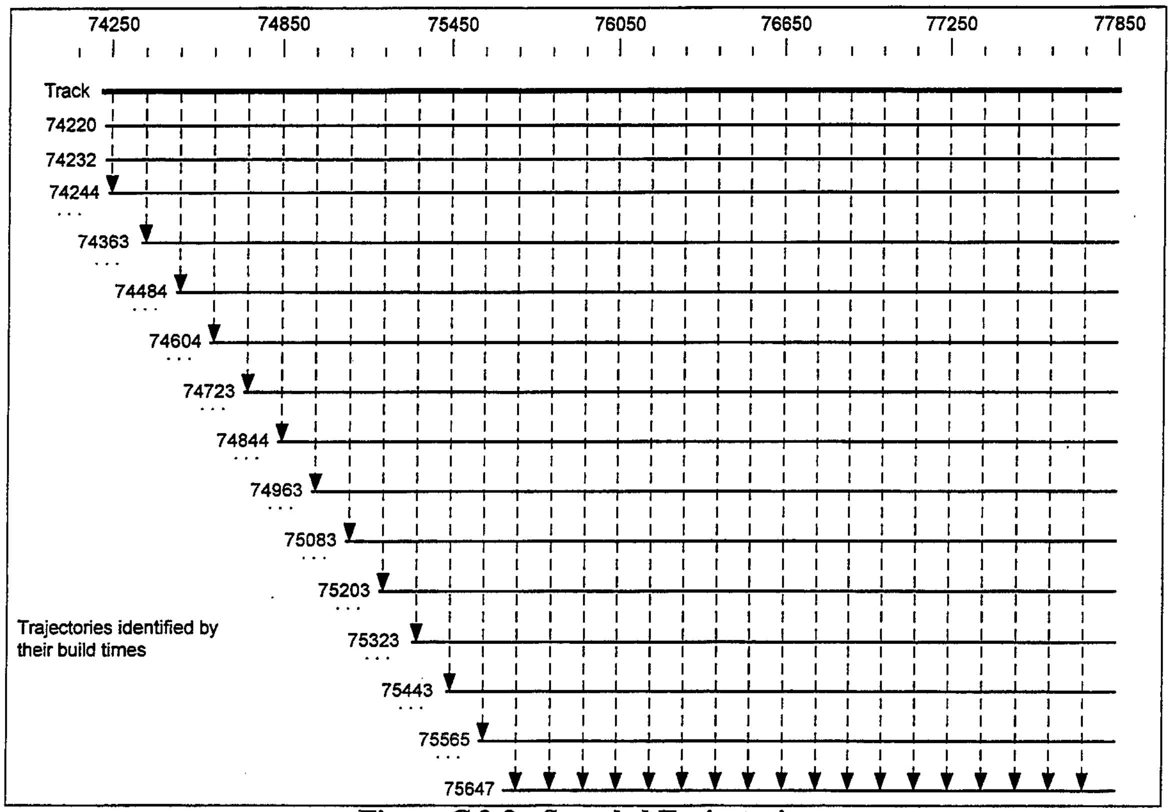

Figure C.2-3: Sampled Trajectories

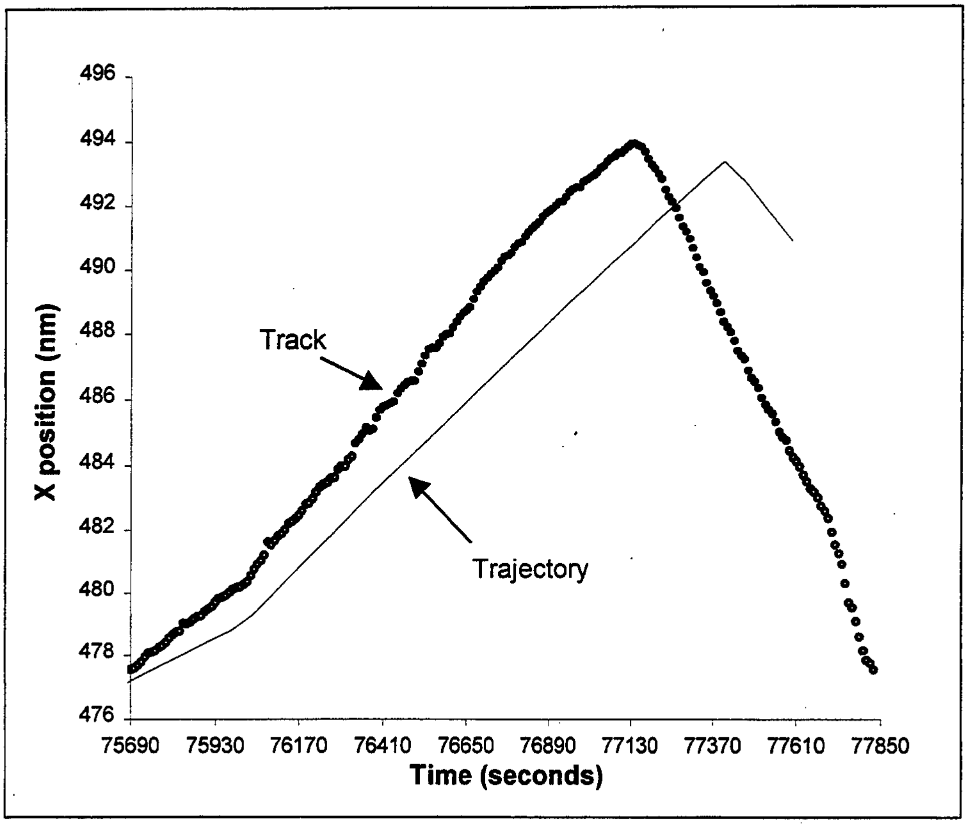

Figure C.2-4: Track X and 75647 Trajectory X

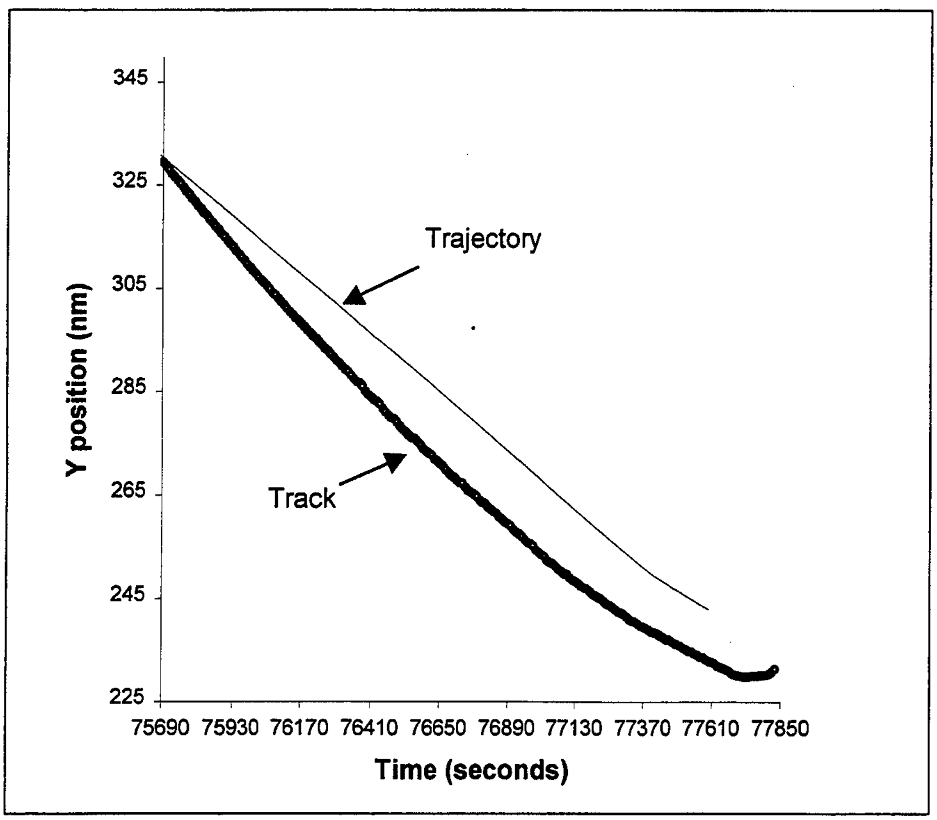

Figure C.2-5: Track Y and 75647 Trajectory Y

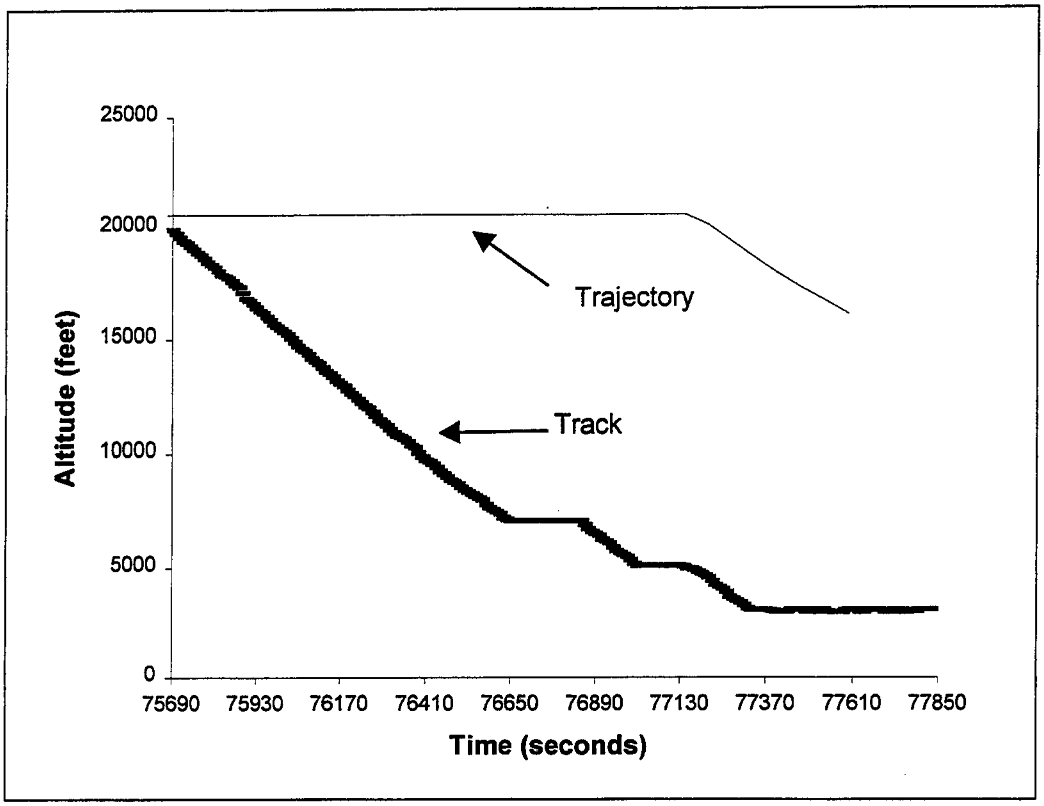

Figure C.2-6: Track and 75647 Trajectory Altitude vs Time

Table C.2-2: Trajectory Metrics (1 of 4)[3]

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
74250	74244	0	0.01	-0.03	0.00
		300	3.49	-0.82	100.00
		600	5.05	-13.08	0.00
		900	7.59	-25.29	0.00
		1200	11.24	-35.63	0.00
		1500	39.59	0.01	-1983.00
		1800	39.76	11.36	-6283.00
74370	74363	0	-0.02	-0.01	0.00
		300	3.15	-4.54	0.00
		600	4.56	-18.17	0.00
		900	7.69	-29.31	0.00
		1200	37.60	-6.36	0.00
		1500	38.23	4.74	-3542.00
		1800	38.17	15.18	-7942.00

[3] In this chart, longitudinal and lateral error are reported in hundredths of nautical miles, and the vertical error is reported in hundredths of feet. The precision of the input HCS altitude data is reported to the nearest 100 feet, the apparent difference is simply an artifact of the track report processing.

Table C.2-2: Trajectory Metrics (2 of 4)

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
74490	74484	0	0.02	-0.04	0.00
		300	1.98	-9.94	0.00
		600	3.95	-23.03	0.00
		900	8.51	-33.32	0.00
		1200	36.14	-2.42	-1083.00
		1500	36.55	9.50	-5442.00
		1800	36.19	19.00	-9642.00
74610	74604	0	0.00	-0.02	0.00
		300	3.01	-0.66	0.00
		600	6.01	0.72	0.00
		900	8.90	3.03	0.00
		1200	12.41	6.45	-2783.00
		1500	15.11	10.67	-7083.00
		1800	16.87	13.69	-11242.00
74730	74723	0	-0.05	-0.06	0.00
		300	4.12	-0.32	0.00
		600	7.94	1.76	0.00
		900	11.80	3.91	-183.00
		1200	16.84	8.33	-4583.00
		1500	19.91	11.95	-8783.00
		1800	22.29	14.81	-12642.00
74850	74844	0	0.01	-0.01	0.00
		300	4.23	0.26	0.00
		600	8.16	2.64	0.00
		900	12.52	5.53	-1983.00
		1200	16.84	9.90	-6283.00
		1500	19.66	13.14	-10342.00
		1800	20.81	15.74	-13900.00
74970	74963	0	-0.03	-0.09	0.00
		300	4.44	-1.41	0.00
		600	8.96	-1.85	0.00
		900	14.44	-0.60	-3542.00
		1200	18.96	0.38	-7942.00
		1500	22.40	0.26	-11983.00
		1800	23.26	-0.31	-13900.00
75090	75083	0	-0.02	-0.04	0.00
		300	4.73	-1.82	0.00
		600	9.47	-1.79	-1083.00
		900	15.12	0.19	-5442.00
		1200	18.90	0.33	-9642.00
		1500	21.64	0.21	-13342.00
		1800	21.68	-0.54	-14442.00

Table C.2-2: Trajectory Metrics (3 of 4)

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
75210	75203	0	-0.01	-0.08	0.00
		300	5.00	-1.84	0.00
		600	10.28	-1.02	-2783.00
		900	15.08	0.18	-7083.00
		1200	18.70	0.15	-11242.00
		1500	20.33	-0.28	-13900.00
		1800	20.18	-0.25	-15900.00
75330	75323	0	0.08	0.00	0.00
		300	4.56	-1.21	-183.00
		600	10.62	-0.31	-4583.00
		900	14.77	0.19	-8783.00
		1200	17.94	0.10	-12642.00
		1500	18.44	-0.47	-13900.00
		1800	17.88	-0.17	-15900.00
75450	75443	0	0.01	-0.04	0.00
		300	5.14	-0.83	-1983.00
		600	10.56	-0.01	-6283.00
		900	14.33	0.18	-10342.00
		1200	16.28	0.04	-13900.00
		1500	16.58	-0.44	-15242.00
		1800	14.36	2.51	-16048.00
75570	75565	0	0.05	-0.01	0.00
		300	5.81	-0.44	-3542.00
		600	10.50	0.26	-7942.00
		900	13.94	0.27	-11983.00
		1200	14.82	-0.38	-13900.00
		1500	14.86	-0.30	-15900.00
		1800	10.77	6.28	-15247.46
75690	75647	0	0.83	-0.28	-683.00
		300	7.11	-0.08	-5042.00
		600	11.01	0.71	-9242.00
		900	13.96	0.26	-12942.00
		1200	14.22	-0.53	-14042.00
		1500	13.32	0.89	-15493.45
		1800	11.92	1.45	-14068.17
75810	75647	0	3.56	-0.39	-2383.00
		300	8.81	0.33	-6683.00
		600	12.57	0.46	-10842.00
		900	14.41	-0.20	-13500.00
		1200	14.47	-0.34	-15500.00
		1500	11.52	4.35	-15614.63
75930	75647	0	6.02	-0.44	-4183.00
		300	10.29	0.51	-8383.00
		600	13.64	0.21	-12242.00
		900	14.35	-0.49	-13500.00
		1200	14.01	-0.25	-15500.00
		1500	11.85	2.07	-14591.77

Table C.2-2: Trajectory Metrics (4 of 4)

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
76050	75647	0	7.94	0.38	-5883.00
		300	11.82	0.65	-9942.00
		600	13.99	0.10	-13500.00
		900	14.48	-0.51	-14842.00
		1200	12.44	2.44	-15565.91
		1500	11.73	1.91	-13523.00
76170	75647	0	9.55	0.55	-7542.00
		300	13.16	0.45	-11583.00
		600	14.24	-0.38	-13500.00
		900	14.47	-0.33	-15500.00
		1200	10.43	6.25	-15157.46
76290	75647	0	11.01	0.71	-9242.00
		300	13.96	0.26	-12942.00
		600	14.22	-0.53	-14042.00
		900	13.32	0.89	-15493.45
		1200	11.92	1.45	-14068.17
76410	75647	0	12.57	0.46	-10842.00
		300	14.41	-0.20	-13500.00
		600	14.47	-0.34	-15500.00
		900	11.52	4.35	-15614.63
76530	75647	0	13.64	0.21	-12242.00
		300	14.35	-0.49	-13500.00
		600	14.01	-0.25	-15500.00
		900	11.85	2.07	-14591.77
76650	75647	0	13.99	0.10	-13500.00
		300	14.48	-0.51	-14842.00
		600	12.44	2.44	-15565.91
		900	11.73	1.91	-13523.00
76770	75647	0	14.24	-0.38	-13500.00
		300	14.47	-0.33	-15500.00
		600	10.43	6.25	-15157.46
76890	75647	0	14.22	-0.53	-14042.00
		300	13.32	0.89	-15493.45
		600	11.92	1.45	-14068.17
77010	75647	0	14.47	-0.34	-15500.00
		300	11.52	4.35	-15614.63
77130	75647	0	14.01	-0.25	-15500.00
		300	11.85	2.07	-14591.77
77250	75647	0	12.44	2.44	-15565.91
		300	11.73	1.91	-13523.00
77370	75647	0	10.43	6.25	-15157.46
77490	75647	0	11.92	1.45	-14068.17

C.2.2 CTAS3

This example illustrates how the lack of pilot intent information in the form of an ATC clearance can cause large trajectory prediction errors in the horizontal and vertical dimensions. It also shows how the CTAS trajectory synthesis can, for rather long periods (e.g. two to 10 minutes), not update the trajectory prediction. When the trajectory did not get updated, the trajectory prediction errors became very large: to 34 nautical miles in the horizontal to 19,000 feet in the vertical.

C.2.2.1 Track Data

The aircraft, Bae125, filed a Flight Plan from Meacham Field (FTW) and return, flying out to Abilene using the King3 for departure and Slugg4 for arrival back at FTW. However, the aircraft did not follow the filed Flight Plan. It climbed out to the west northwest to an altitude of 39,000 feet, made a big looping turn and came back to FTW.

The track data used for this aircraft began at the time 22:22:28 (80548 seconds) and was interpolated each ten seconds over the interval from 22:22:30 (80550 seconds) through 22:50:10 (82210 seconds). During this period the HCS supplied 240 track reports for this aircraft.

C.2.2.1.1 Time Adjustment

The time stamps assigned by CTAS were first rounded to the nearest second and then adjusted to 12 second intervals or to intervals of multiples of 12 seconds. Table C.2-3 shows the time intervals after rounding and before adjustment, after adjustment, and after correction processing.

Table C.2-3: Track Report Time Intervals for CTAS3

Gap Size (Seconds)	Count Before Adjustment	Count After Adjustment	Count After Processing
11	45	0	0
12	139	233	232
13	49	0	0
23	2	0	0
24	4	6	0
132	0	0	1

After the time adjustment there remained six gaps in the track data where one report was missing. All of these gaps were patched by interpolation. That is, six track reports were added to the track to fill in these small gaps. There were two instances in the track where the aircraft did not move between radar position reports. The XYZ values for these two track reports were replaced with interpolated values. There was one instance where the aircraft moved between reports, but for only a short distance (0.08 nautical miles). The XYZ values were replaced here also. The first two track reports were discarded because the altitude changed from 41,000 feet to 5300 feet. In one place in the track, adjacent track reports were inconsistent and the attempt to bridge the gap failed. Ten track reports were dropped and the track was re-initialized. Dropping the reports created a gap of 132 seconds in the track data. The track report correction processing deleted the first two reports, added six interpolated reports, filled the six 24 second gaps, and deleted 10 reports where the data was inconsistent. As a result, the 240 track reports, after correction processing, became 234 reports. The track as corrected then had one 132 second gap. In this study no more measurements are made on the track after such a break.

Figure C.2-7 presents a plot of the interpolated XY track data and the route as specified by the FP record. Figure C.2-8 presents the interpolated altitude track data plotted against time. The flight

plan indicates that the pilot's intent was to depart from Meacham Field (FTW), fly out to the Abilene fix (ABI) using the King3 departure and then return to FTW using the Slugg4 arrival. However, the recorded track data shows that this aircraft flew a route climbing to the northwest to an altitude of 39,000 feet, then made a clockwise turn and returned to FTW. Most likely, once the aircraft departed, ATC verbally allowed him to fly this new route, but CTAS had no knowledge of the route change. This led to large errors in the trajectory predictions.

C.2.3.2 Trajectories

Figure C.2-9 presents the track time line (labeled "Track") and the time line for 27 of the 41 trajectories recovered for this aircraft. Each of the trajectories is labeled with the trajectory's build time. The first sampling of the trajectory accuracy is shown in Figure C.2-9 by an arrow drawn from the track time line to the latest trajectory available at that sample time. The first sample starts 40 seconds after the time of the initial interpolated track, which in this example was 80590 seconds.

The trajectory sampled for the starting sample time (time = 80590 seconds) was the 80583 trajectory, since this was the latest trajectory available prior to the sample time. The first four trajectories are not used, since there was no track data available to associate these early trajectories. The sampling interval used in this study was 120 seconds. The trajectory used for the next sample time (time = 80590+120 = 80710 seconds) was also the 80583 trajectory, as it was until the sampling time of 81310 when the 81303 trajectory began to be used. This process of associating the last valid trajectory with a sample time was continued for the entire track. As a result six of the 41 trajectories were used: 80583, 81303, 81615, 81890, 82023 and 82119. The remaining trajectories were not used in the study since they were created for track points after the last available track point.

C.2.3.3 Metrics

The XY plots of these six trajectories are shown in Figure C.2-10 along with the interpolated track data. CTAS initially predicted a flight path following the Flight Plan. It then gave up on following the Flight Plan and predicted a series of return paths, each returning to FTW.

Besides the error due to the re-routing of this aircraft, this example illustrates a second, perhaps related, error source. Normally a CTAS trajectory is captured for each track point, but for this aircraft there were three time gaps where trajectories were not updated. The first gap occurred for 624 seconds between the 80583 and 81207 trajectories, the second occurred for 253 seconds between the 81303 and 81556 trajectories, and the third occurred for 213 seconds between the 81615 and 81818 trajectories.

Three of the 14 error measurements with a look ahead time of zero seconds were produced from three different sample trajectories (i.e. the 80583, 81303, and 81615 trajectories) with ages of 607, 247, and 175 seconds. These samples have horizontal errors of 14, 34, and 20 nautical miles and vertical errors of 18,900, 14,500, and 3,600 feet, respectively

The significance of these gaps is also shown in Figure C.2-11, which shows plots of the interpolated track XY and the uninterpolated trajectory XY position points for the 80583 trajectory. This figure also identifies the points at which trajectory metrics were calculated for sample time = 80590 seconds at look ahead times of zero, 300, 600, 900, 1200, and 1500. Figure C.2-12 shows the vertical trajectory metrics for the sample points on the 80583 trajectory. These metrics are presented, along with all the trajectory metrics calculated for this aircraft, in Table C.2-4.

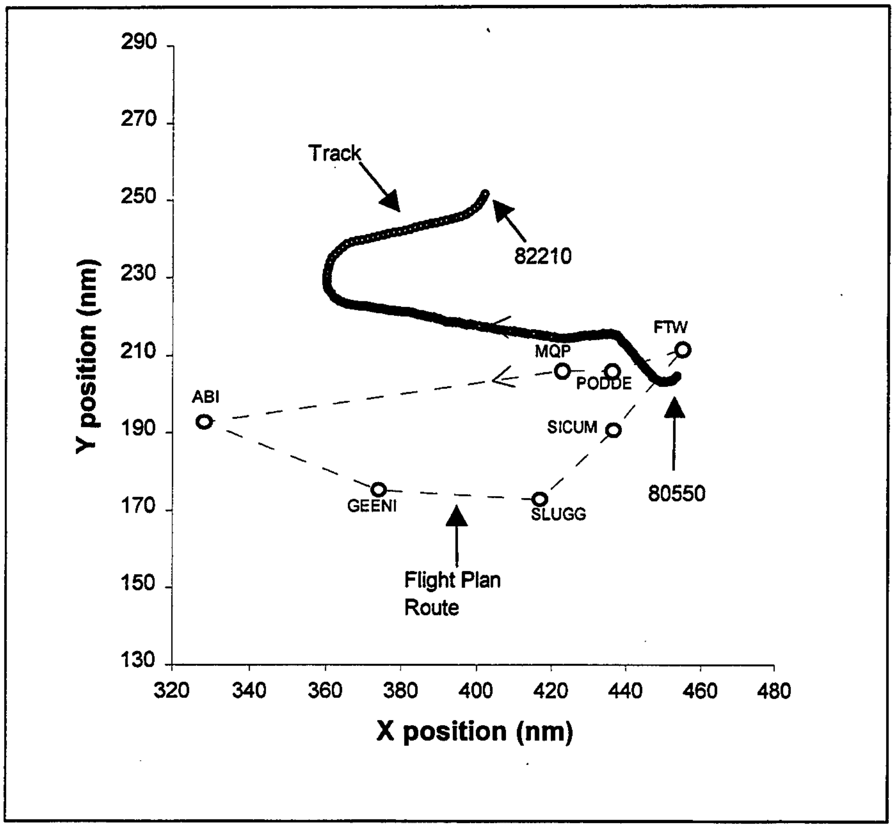

Figure C.2-7: Interpolated Track and Route XY Position

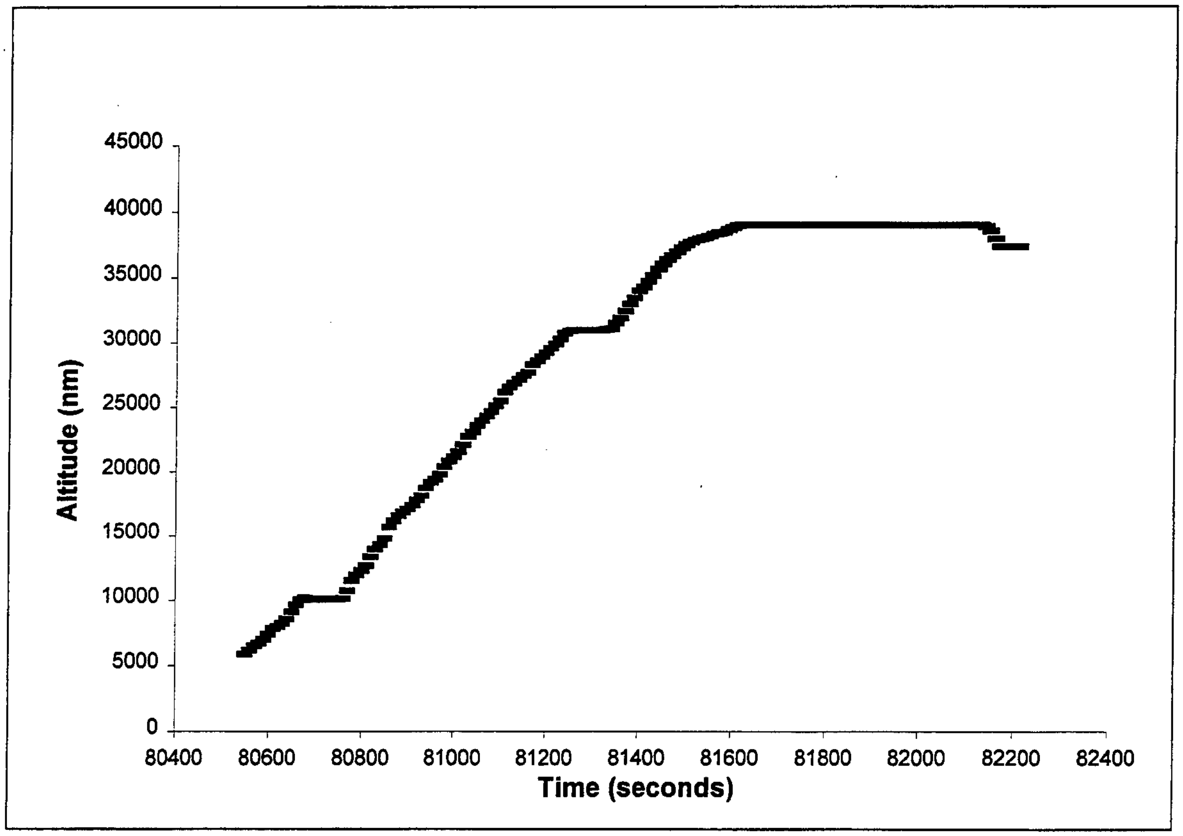

Figure C.2-8: Interpolated Track Altitude

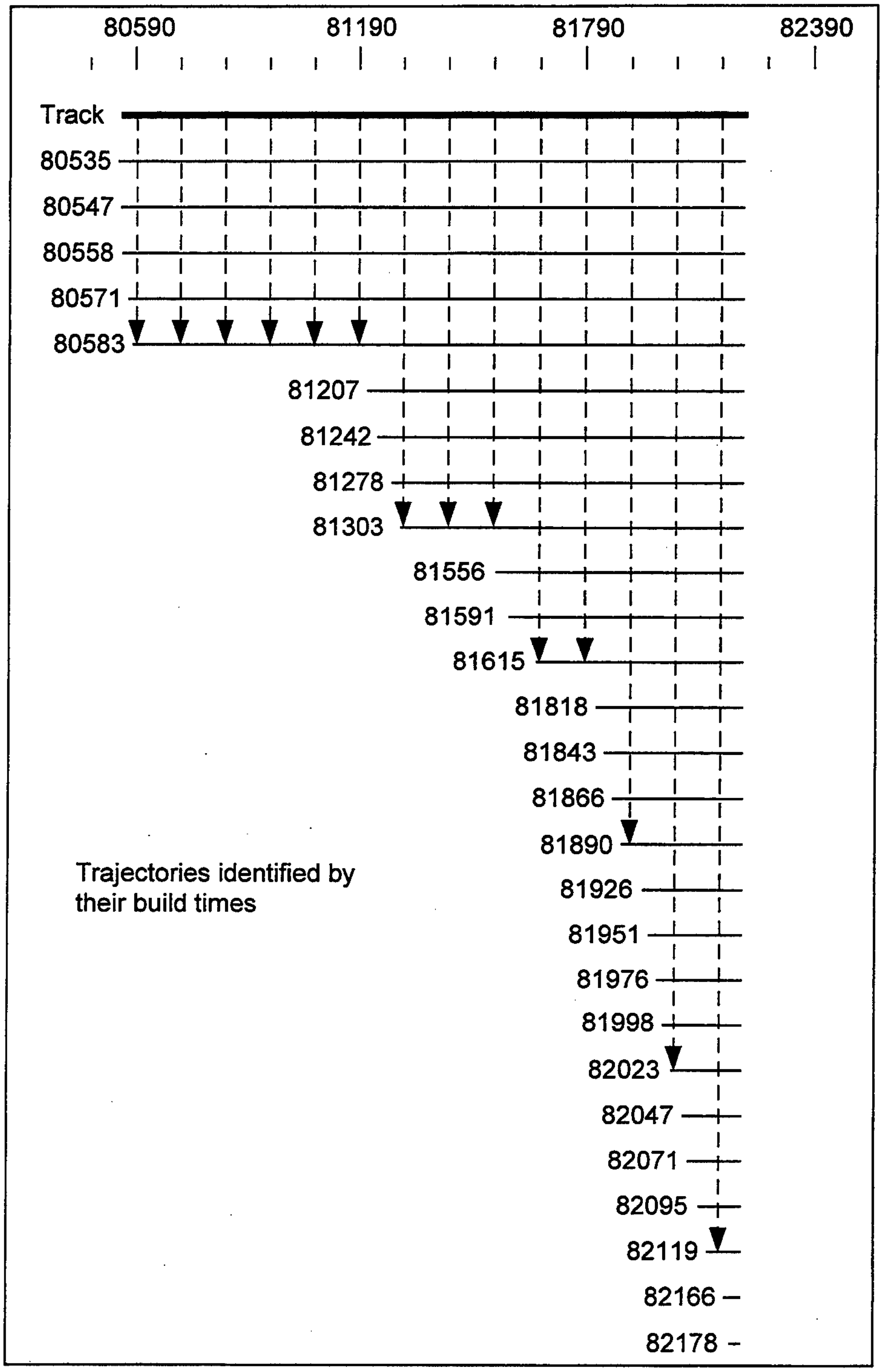

Figure C.2-9: Sampled Trajectories

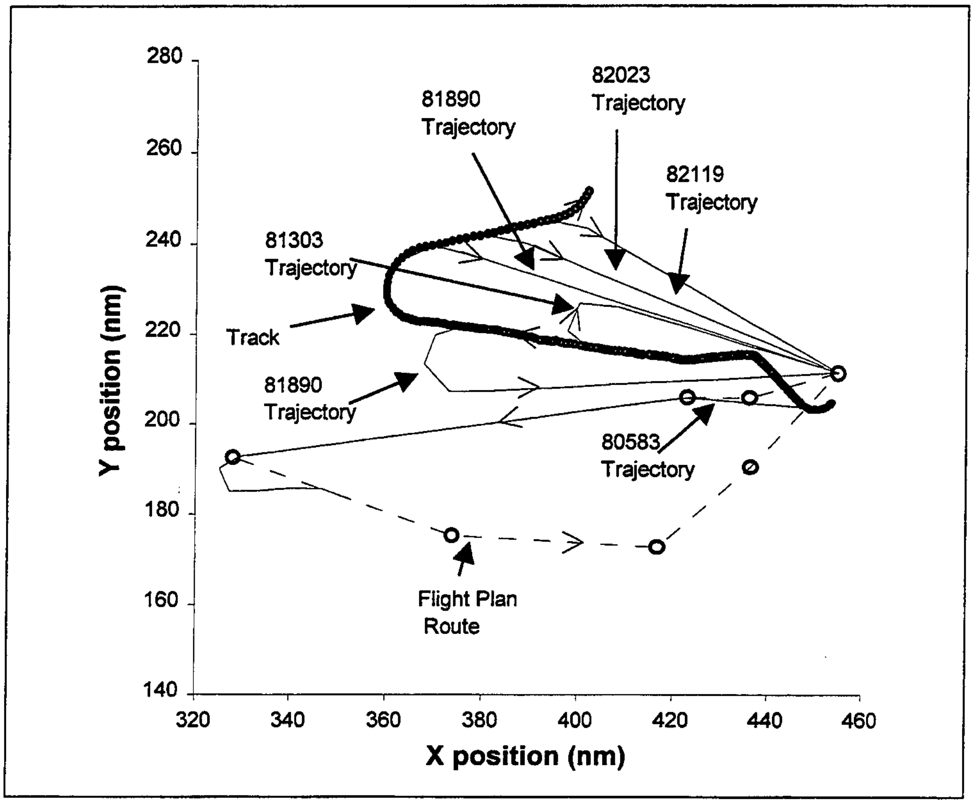

Figure C.2-10: Track, Sampled Trajectories, and Route

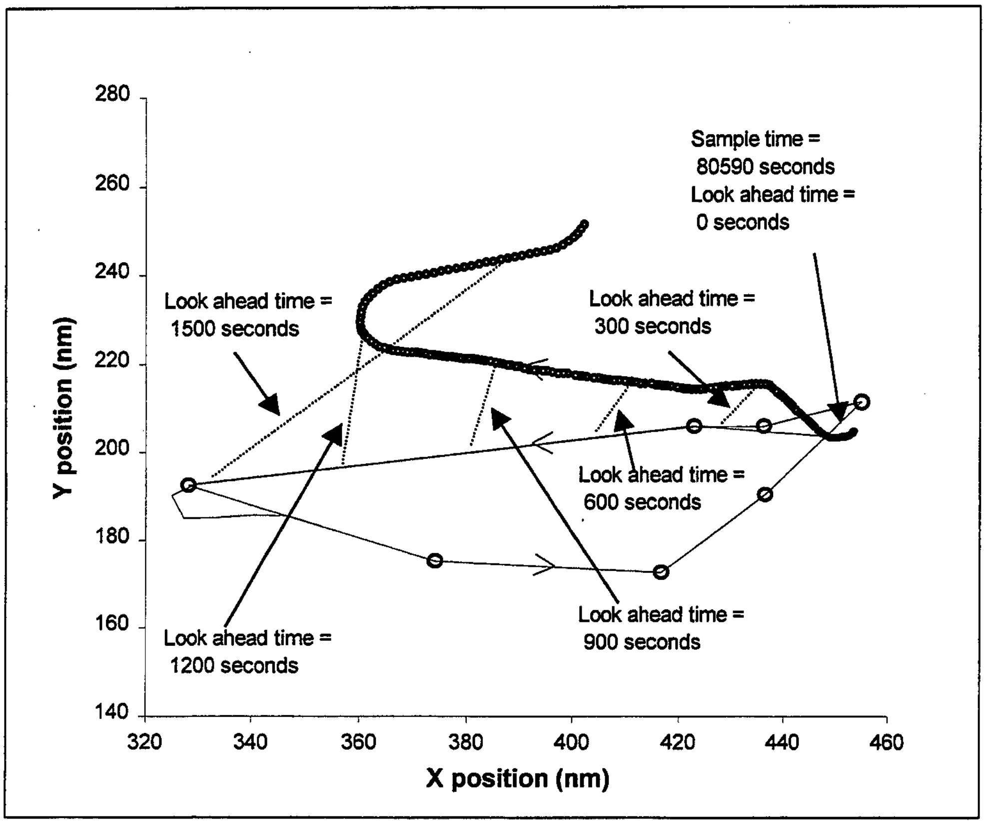

Figure C.2-11: Sampled XY Points Along 80583 Trajectory

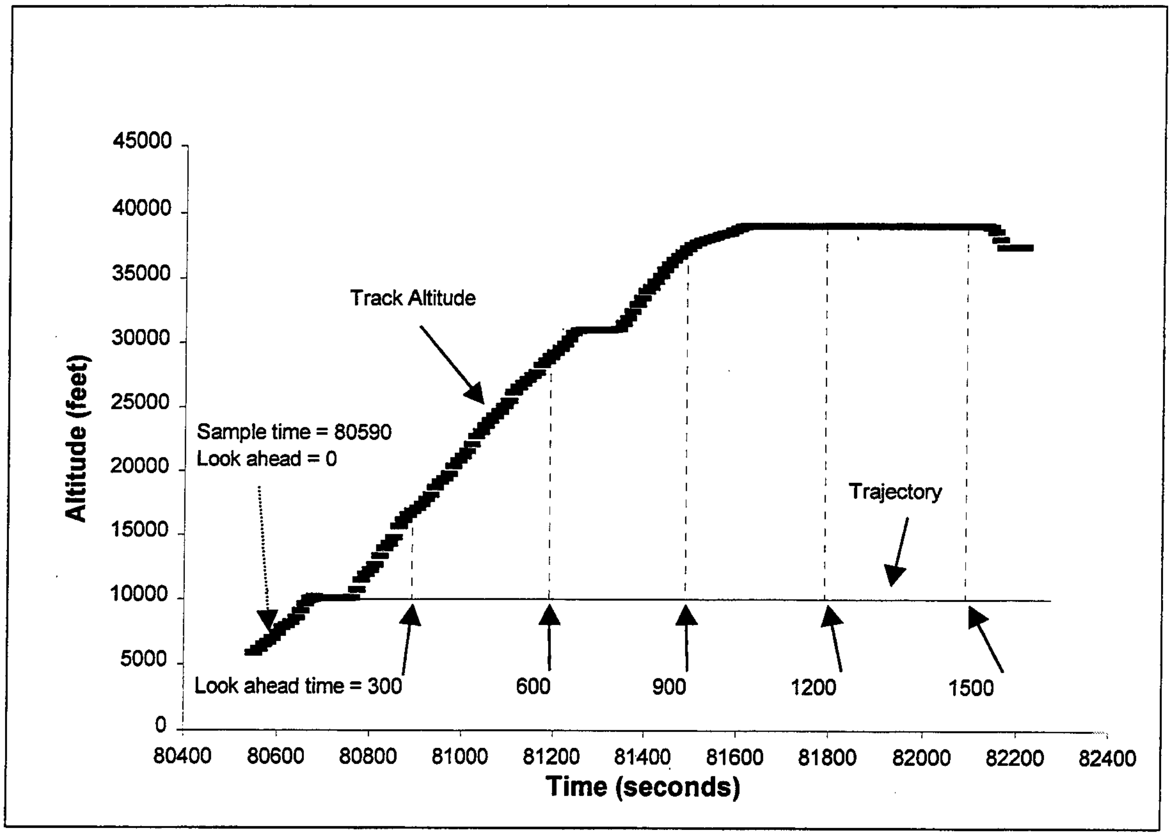

Figure C.2-12: Sampled Altitude Points Along 80583 Trajectory

Table C.2-4: Trajectory Metrics

Sample Time	Traj Build Time	Look Ahead Time	Long Error	Lat Error	Vert Error
80590	80583	0	-0.32	-0.04	-74.08
		300	-6.88	10.74	6840.00
		600	-8.59	11.40	18889.00
		900	-7.48	19.31	27290.00
		1200	-7.76	28.44	28990.00
		1500	-61.99	42.67	28990.00
80710	80583	0	-1.98	2.74	120.69
		300	-9.06	8.20	11539.00
		600	-8.26	14.24	20990.00
		900	-7.66	22.13	28940.00
		1200	-22.05	39.81	28990.00
80830	80583	0	-5.31	8.65	3940.00
		300	-8.67	10.11	16840.00
		600	-7.32	17.55	25190.00
		900	-7.33	24.98	28990.00
		1200	-48.76	41.78	28990.00
80950	80583	0	-7.07	9.94	9140.00
		300	-8.40	12.73	20940.00
		600	-7.50	20.95	28190.00
		900	-12.40	34.26	28990.00
		1200	-85.87	12.16	28590.00
81070	80583	0	-8.52	8.60	14290.00
		300	-7.69	15.94	22439.00
		600	-7.62	23.64	28990.00
		900	-35.19	41.15	28990.00
81190	80583	0	-8.59	11.40	18889.00
		300	-7.48	19.31	27290.00
		600	-7.76	28.44	28990.00
		900	-61.99	42.67	28990.00
81310	81303	0	-0.32	-0.14	1.08
		300	-43.26	13.70	17550.03
81430	81303	0	-10.48	5.70	6732.92
		300	-67.20	15.35	22145.94
81550	81303	0	-31.16	12.81	14477.60
		300	-87.99	9.03	26788.20
81670	81615	0	-1.02	2.18	0.00
		300	-20.07	-33.54	10277.69
81790	81615	0	-19.46	-3.27	3551.77
		300	-17.75	-36.48	14393.46
81910	81890	0	-0.17	-0.79	685.23
82030	82023	0	-0.13	-0.37	242.42
82150	82119	0	-0.81	-1.85	758.92